



AEROSPACE RECOMMENDED PRACTICE

ARP 1525

Society of Automotive Engineers, Inc.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

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Revised

HYDROGEN EMBRITTLEMENT EFFECT ON METALS BY AIRCRAFT MAINTENANCE CHEMICALS Mechanical Test Methods

1. **SCOPE:** This recommended practice defines a procedure for evaluating the hydrogen generating potential of fluids used for aircraft maintenance. The procedures and requirements are specified for three types of test specimens fabricated from AISI 4340 low-alloy steel. It should be noted, however, that any aircraft maintenance fluid found to be non-embrittling to AISI 4340 low-alloy steel cannot be assumed to be non-embrittling to other types of steel.
 - 1.1 **Classification:** Types of hydrogen embrittlement test specimen geometries and loading conditions shall conform to the following types as specified:
 - Type 1a - Notched round bars, stressed in tension, under constant load.
 - Type 1b - Notched round bars, loaded in bending with loading bars.
 - Type 2 - Unnotched ring specimens, loaded in bending with displacement bars.
 2. **SIGNIFICANCE:** This recommended practice establishes tests that may be useful for determining the hydrogen-embrittlement potential of cleaners, paint strippers, and other aircraft maintenance chemicals which may contact cadmium-plated high-strength steel parts during service life. The test may also be useful in the development of non-embrittling materials and processes that are designed to be used on high-strength steel.
 3. **APPLICABLE DOCUMENTS:**
 - 3.1 **SAE Publications:** Available from Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096.
 - AMS 2400 - Cadmium Plating
 - AMS 2760 - Heat Treatment, Carbon, Low-Alloy, and Specialty Steels
 - AMS 6415 - Steel Bars, Forgings, and Tubing, 0.80Cr - 1.8Ni - 0.25Mo (0.38 - 0.43C) (SAE 4340)
 - 3.2 **ASTM Publications:** Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.
 - ASTM A370 - Mechanical Testing of Steel Products
 - ASTM E3 - Preparation of Metallographic Specimens
 - ASTM E138 - Wet Magnetic Particle Inspection
 - ASTM E292 - Conducting Time-for-Rupture Notch Tension Tests of Materials
 - 3.3 **Government Publications:** Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

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3.3.1 Federal Specifications:

QQ-P-416 - Plating, Cadmium (Electrodeposited)

3.3.2 Military Specifications:

MIL-S-851 - Steel Grit, Shot and Cut Wire Shot, and Iron Grit
and Shot-blast Cleaning and Peening
MIL-S-5000 - Steel, Chrome-Nickel-Molybdenum (4340) Bars and
Reforging Stock
MIL-H-6875 - Heat Treatment of Steels (Aircraft Practice),
Process for
MIL-C-16173 - Corrosion Preventive Compound, Solvent Cutback,
Cold Application

4. TEST SPECIMENS:

4.1 Material: Shall be a low-alloy steel conforming to AMS 6415 or to MIL-S-5000.

4.1.1 The sensitivity to hydrogen embrittlement of each heat of steel used for test specimens shall be established by exposing three test specimens each to two different embrittling environments after heat treatment as in 4.2 and inspection as in 4.6. A heat of steel will be suitable for test purposes only if, after loading Type 1a and Type 1b specimens to 75% of notch tensile strength and Type 2 specimens to 92% of the ultimate tensile strength, all three specimens plated as in 4.1.1.1 fail within 24 hr and all three specimens plated as in 4.1.1.2 do not fail within 7 days.

4.1.1.1 Three specimens shall be electroplated in the following cadmium cyanide bath and under the specified conditions:

Bath Composition	oz/gal	(g/L)
Cadmium (as CdO)	4.5	(35.2)
Sodium Cyanide (NaCN)	14	(109.4)
Ratio of NaCN to CdO	3	(3)
Sodium Hydroxide (NaOH)	2.5	(19.5)
Brightner, Rohco 20XL or equivalent	2.0	(15.6)
Plating Conditions		
pH	12	
Temperature	21° - 32°C	(70° - 90° F)
Current	10 amp/ft ²	(107.6 A/m ²)
Time	30 min.	
Post Treatment (4.1.1.1.1)		
Baking Temperature	190°C ± 15	(375° F ± 25)
Time at temperature	8 hr ± 0.25	

4.1.1.1.1 Do not bake Type 1 specimens.



- 4.1.1.2 Three specimens shall be electroplated in the following cadmium cyanide bath and under the conditions specified hereinafter:

Bath Composition	oz/gal	(g/L)
Cadmium (as CdO)	4.5	(35.2)
Sodium Cyanide (NaCN)	14	(109.4)
Ratio NaCN to CdO	3	(3)
Sodium Hydroxide (NaOH)	2.5	(19.5)

Plating Conditions		
pH	12	
Temperature	21° - 32°C (70° - 90° F)	
Current	60 amp/ft ² (645.8 A/m ²)	
Time	6 min.	

Post Treatment	
Baking Temperature	190°C ± 15 (375° F ± 25)
Time at Temperature	23 hr ± 0.25

- 4.2 Heat Treatment: Specimens shall be hardened and tempered in accordance with AMS 2760 or MIL-H-6875 to a tensile strength of 260,000 - 280,000 psi (1793 - 1931 MPa). The 0.2% offset yield strength shall be not lower than 80% of the ultimate tensile strength. Tensile properties shall be determined in accordance with ASTM A370.
- 4.3 Lot of Specimens: Shall be those specimens fabricated from the same heat of steel in the same orientation, heat treated together in the same furnace, quenched together in the same bath, and subjected to the same additional manufacturing processes at the same time.
- 4.4 Dimensions: Specimens shall conform to the following dimensions:
- 4.4.1 Type 1a: Shall be as specified in Fig. 1.
- 4.4.2 Type 1b: Shall be as specified in Fig. 2.
- 4.4.3 Type 2: Shall be as specified in Fig. 3.
- 4.5 Fabrication:
- 4.5.1 Type 1a and Type 1b specimens shall be machined to size after heat treatment as in 4.2. Crush grinding shall be used to produce the notch.
- 4.5.2 Type 2 ring specimens shall be machined to size from normalized and stress-relieved tubing or bar stock prior to hardening and tempering as in 4.2. After hardening and tempering to 51 - 54 HRC, one specimen from each lot shall be tested to verify that there is no decarburization. All specimens shall be deburred by hand using silicon carbide paper. Surfaces shall be shot-peened using clean shot of size P-190 or S-230 conforming to MIL-S-851. The required shot intensity shall be Almen "A" 0.006 - 0.010 in. (0.15 - 0.25 mm).
- 4.5.2.1 Lightly blast after final heat treatment and again after shot peening using 150 mesh or finer aluminum oxide, a 3/8 - 1/2 in. (9.5 - 12.7 mm) diameter nozzle, 30 - 50 psi (207 - 345 kPa) air pressure, approximately 10 in. (254 mm) from part surface, and moving continuously.

4.5.2.2 Acid or cathodic electrolytic cleaning shall not be used.

4.5.2.3 Straightening after final heat treatment is prohibited.

4.5.2.4 Grinding after final heat treatment is prohibited.

4.6 Inspection:

4.6.1 Type 1a and Type 1b Specimens: Shall be suitable for test purposes if the sampling and inspection results conform to the following requirements:

Type	Property	Sampling of Each Lot	Requirements
1a, 1b	Hardness (4.6.1.1)	5%	51 - 54 HRC, determined in accordance with ASTM A370
1a, 1b	Notch Surface Quality (4.6.1.1)	10%	No grinding burns or untempered martensite, determined by discoloration method or nital etch methods of ASTM E3
1a, 1b	Dimensions	100%	Conform to tolerances specified in Fig. 1 and Fig. 2. Notch dimensions verified by shadow-graphic projection at 100X.
1a, 1b	Non-Destructive Tests	100%	No cracks permitted in any location, determined by magnetic particle inspection in accordance with ASTM E138.
1a	Notch Tensile Strength	10 specimens	Shall be within 10,000 psi (69.5 MPa) of the average, determined in accordance with ASTM A370.
1b	Notch Bend Strength	10 specimens	Number of turns of the loading bolt to produce failure in each specimen shall be within 5% of the average.

4.6.1.1 If the hardness or notch surface quality requirements of any of the sampled specimens do not conform to specified requirements, only those specimens of the lot that are individually inspected for conformance to these requirements may be used for testing.

4.6.2 Type 2 Ring Specimens: Shall be suitable for test purposes if each specimen conforms to the following requirements:

Property	Requirements
Hardness	51 - 54 HRC, determined in accordance with ASTM A370.
Dimensions	Conform to dimensions and tolerances specified in Fig. 3.
Surface Quality	No indications longer than 1/32 in. (0.8 mm), determined by magnetic particle inspection in accordance with ASTM E138.
Scratches	None permitted.

4.6.2.1 Only specimens meeting acceptance criteria for hardness, dimensions, and surface quality may be used for testing.