

AEROSPACE MATERIAL SPECIFICATION

SAE

AMS 2753B

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An American National Standard

Superseding AMS 2753A

LIQUID SALT BATH FERRITIC NITROCARBURIZING Non-Cyanide Bath

1. SCOPE:

1.1 Purpose:

This specification covers the engineering requirements for producing a thin epsilon-iron nitride case on parts by means of a low-temperature, aerated, fused salt bath process and the properties of the case.

1.2 Application:

This procedure has been used typically for increasing the resistance to wear and fatigue on ferrous alloys including carbon steels, low-alloy steels, oil- and air-hardening tool steels, and corrosion-resistant steels, cast irons, and ferrous powder metal products, but usage is not limited to such applications.

1.2.1 This process is not recommended for use on parts which have been plated with silver, copper, zinc, or cadmium or on parts having copper alloy inserts.

1.3 Safety - Hazardous Materials:

While the materials, methods, applications, and processes described or referenced in this specification may involve the use of hazardous materials, this specification does not address the hazards which may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

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2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

2.1.1 Aerospace Material Specifications:

AMS 2759 Heat Treatment of Steel Parts, General Requirements

2.1.2 Aerospace Recommended Practices:

ARP1820 Chord Method of Evaluating Surface Microstructural Characteristics

2.1.3 SAE Standards:

SAE J423 Methods of Measuring Case Depth

2.2 ASTM Publications:

Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

ASTM E 140 Hardness Conversion Tables for Metals (Relationship Between Brinell Hardness, Vickers Hardness, Rockwell Hardness, Rockwell Superficial Hardness, and Knoop Hardness)

ASTM E 384 Microhardness of Materials

2.3 U.S. Government Publications:

Available from Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

2.3.1 Military Standards:

MIL-STD-2073-1 DOD Materiel, Procedures for Development and Application of Packaging Requirements

2.4 ASM Publications:

Available from ASM International, Materials Park, OH 44073

ASM Handbook, Metallography and Microstructure, 9th Edition.

3. TECHNICAL REQUIREMENTS:

3.1 Processing Equipment:

3.1.1 Nitrocarburizing Salts: Shall consist primarily of a mixture of alkali metal cyanates and carbonates.

3.1.2 Salt Bath: The cyanate content of the bath shall be controlled within the range 34 - 38% by weight, determined as cyanate ion.

3.1.3 Parts to be nitrocarburized should be processed in a salt bath retort-type furnace conforming to AMS 2759. Furnace temperature uniformity requirements shall be ± 15 °F (± 8 °C).

3.1.4 Furnace Controls: Shall conform to AMS 2759.

3.1.5 Thermocouples: When load thermocouples are required, they shall be sheath protected to prevent deterioration due to immersion in nitrocarburizing salts.

3.1.6 Aeration: The bath shall be aerated with clean, dry, oil-free compressed or plant air. A desiccant air dryer, a flowmeter for measuring air flow, a gauge for air pressure, and a sparging ring are required equipment. The air flow and pressure shall be in accordance with the salt producer's recommendations.

3.2 Pretreatment:

3.2.1 Hardening: Parts requiring core hardening prior to nitrocarburizing, shall be heat treated in accordance with AMS 2759, or other procedure acceptable to purchaser, to the required core hardness. Tempering for the specified core hardness shall be done at a temperature not lower than 20 °F (11 °C) above the highest nitrocarburizing temperature to be used.

3.2.2 Surface Condition: Prior to nitrocarburizing, parts shall be clean and free of scale, oxide, entrapped sand, mold or core sand material, metal particles, oil, or grease. Parts must be completely dry. Surfaces to be nitrocarburized shall be mechanically or chemically cleaned subsequent to stress relieving and prior to nitrocarburizing.

3.2.3 Stress Relief: Parts in which residual stresses may have been introduced by prior mechanical working or other causes and consequently may crack or change dimensionally during nitrocarburizing shall be stress relieved prior to final part machining. Stress relief shall be performed in accordance with AMS 2759 at a temperature not lower than 20 °F (11 °C) above the nitrocarburizing temperature.

3.3 Procedures:

3.3.1 Preheating: Parts shall be preheated in air to a temperature not higher than 750 °F (399 °C), to ensure drying, to maintain bath temperature, and to avoid thermal shock upon immersion in the nitrocarburizing salt.

3.3.2 Nitrocarburizing: Parts shall be immersed and held at temperature in the aerated cyanate bath as follows:

Material	Time		Approximate Temperature	
	min	max	°F	°C
Carbon and Low-Alloy Steels	1 hour	2 hours	1070	577
Tool and Die Steels	5 minutes	3 hours	1000	538
Corrosion and Heat Resistant Steels (3.3.2.1)	15 minutes	2 hours	1070	577
Ductile, Malleable, and Gray Cast Iron	1 hour	3 hours	1070	577
Ferrous Powder Metal Products	30 minutes	2 hours	1070	577

3.3.2.1 Nitrocarburizing temperature should be at least 20 °F (11 °C) below final tempering temperature or precipitation hardening temperature to maintain base material hardness but shall not be lower than 1000 °F (538 °C).

3.3.3 Quenching: Following nitrocarburizing, parts shall be intermediate quenched in a fused salt bath in a temperature range of 650 to 750 °F (343 to 399 °C). After parts have stabilized at the bath temperature set point, water quench or air cool.

3.4 Properties:

Nitrocarburized parts shall conform to the following requirements, determined on parts or on test specimens as in 4.3.1:

3.4.1 Test for Compound Layer Presence: The required presence of a compound layer on non-austenitic steels and cast irons shall be confirmed by means of a chemical spot test. A drop of copper ammonium chloride (3.4.1.1) or copper sulfate solution (3.4.1.2) applied to a clean nitrocarburized surface of a part shall turn a reddish-brown color after 15 seconds. If copper plates out on the surface after this procedure, the compound layer is not present and the part is subject to rejection.

3.4.1.1 Copper ammonium chloride solution: dissolve 100 grams cupric chloride ($\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$) in distilled water to make one liter. Add ammonium hydroxide to form a copper ammonium chloride complex.

3.4.1.2 Copper sulfate solution: dissolve 40 grams copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$) in 1000 mL distilled water and 5 mL wetting agent, (i.e. glycerin); pH shall be 3.5 - 4.1.

- 3.4.2 Depth of Compound Layer: Shall be as follows, determined in accordance with the taper or step grind procedures of SAEJ423 or ARP1820, microscopic method at not less than 500X magnification.

Material	Compound Layer Thickness			
	Inch		Millimeter	
	min	max	min	max
Carbon Steel	0.00015	0.0010	0.0038	0.025
Corrosion & Heat Resistant Steels	0.00015	0.0010	0.0038	0.025
Low-Alloy Steel	0.00015	0.0010	0.0038	0.025
Tool and Die Steels	0.0001	0.0005	0.0025	0.012
Cast Iron	0.00015	0.0010	0.0038	0.025
Ferrous Powder Metal Products (minimum density 7.0 gm/cc)	0.00015	0.0010	0.0038	0.025

- 3.4.3 Quality of Compound Layer:

3.4.3.1 Not less than three fields shall be examined at 500X magnification employing acceptable quantitative metallographic procedures of line intercept or grid analysis (as described in ASM Handbook, 9th Edition, Metallography and Microstructure, pages 123 to 134). The upper half of the total compound-thickness, as in 3.4.2, shall not contain more than 50% residual porosity and oxides in any one field viewed. The compound layer at the substrate interface and the lower quarter of the total compound thickness shall not exhibit residual porosity and oxides exceeding 5% for steel and corrosion-resistant steel components and 15% for cast iron components.

3.4.3.2 For parts treated in liquid ferritic nitrocarburizing baths using sulfur bearing salts, the resultant compound layer shall be free of sulfur. Quantitative surface analysis shall be done to verify the absence of sulfur.

3.4.4 Case Hardness: Shall be as follows, determined by microhardness measurements at a depth of 0.001 inch (0.025 mm) from the treated surface in accordance with ASTM E 384 or by the chord method of ARP1820 on prepared cross sections of the nitrocarburized case using Knoop or other appropriate hardness tester acceptable to the cognizant engineering activity.

Material	Hardness, minimum HK100 or equivalent
Carbon Steels	300
Low-Alloy Steels	460
Tool & Die Steels	600
Cast Iron (Gray, Ductile, or Malleable)	300
Corrosion & Heat Resistant Steel	600
Ferrous Powder Metal Products (minimum density 7.0 g/cc)	300

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The processor of treated parts shall supply all samples for processor's tests and shall be responsible for performing all required tests. Purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that the parts conform to the requirements of this specification.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests for core hardness (3.2.1), presence of compound layer (3.4.1), depth of compound layer (3.4.2), quality (3.4.3), and case hardness (3.4.4) are acceptance tests and shall be performed on each heat treatment lot.

4.2.2 Periodic Tests: Tests for cyanate content (3.4.2) are periodic tests and shall be performed at a frequency selected by the vendor unless frequency of testing is specified by purchaser.

4.2.3 Preproduction Tests: Tests for all technical requirements are preproduction tests and shall be performed prior to or on the first-article shipment of nitrocarburized parts to a purchaser, when a change in material and/or processing requires reapproval as in 4.4.2, and when purchaser deems confirmatory testing to be required.

4.2.3.1 For direct U.S. Military procurement, substantiating test data and when requested, preproduction test material shall be submitted to the cognizant agency as directed by the procuring activity, contracting officer, or request for procurement.

4.3 Sampling and Testing:

Not less than one sample shall be processed for evaluation for each test requirement:

4.3.1 Evaluation Samples: Test pins or specimens of the same nominal composition as the parts shall be processed with the work when required by purchaser.

4.4 Approval:

4.4.1 Nitrocarburized parts shall be approved by purchaser before parts for production use are supplied, unless such approval be waived by purchaser. Results of tests on production parts shall be essentially equivalent to those on the approved sample parts.

4.4.1.1 Specimens of the same nominal composition and heat treat condition (See 4.3.1) may be used for destructive evaluation in lieu of actual parts if acceptable to the cognizant quality assurance activity.