

GASEOUS NITROCARBURIZING

1. SCOPE:

- 1.1 **Purpose:** This specification covers the engineering requirements for producing a continuous thin epsilon iron carbonitride compound layer on parts by means of a gaseous, low-temperature process, as well as the properties of the case.
- 1.2 **Application:** This process is primarily applied to increase the resistance to wear and fatigue and to improve corrosion resistance of ferrous metals such as carbon, low alloy, and tool steels, and of cast irons.
2. **APPLICABLE DOCUMENTS:** The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications and Aerospace Recommended Practices shall apply. The applicable issue of other documents shall be as specified in AMS 2350.
- 2.1 **SAE Publications:** Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2408 - Tin Plating
AMS 2418 - Copper Plating
AMS 2429 - Bronze Plate Masking
AMS 2759 - Heat Treatment of Steel Parts, General Requirements

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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 American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM E384 - Microhardness of Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.1 Military Standards:

MIL-STD-794 - Parts and Equipment, Procedure for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Processing Equipment: Parts to be nitrocarburized shall be processed in an integral quench, sealed retort, fluidized bed, or atmosphere-type furnace conforming to AMS 2759. Furnace temperature uniformity requirements shall be $\pm 15^{\circ}\text{F}$ ($\pm 8^{\circ}\text{C}$).

3.1.1 Atmosphere: The nitrocarburizing atmosphere shall consist of a mixture of ammonia diluted with a carrier gas. Acceptable carrier gases are: endothermic (AGA type 302), refined exothermic gas (AGA Type 201), and high purity nitrogen; a hydrocarbon gas may be used for enrichment.

3.1.2 Furnace Controls: Shall conform to AMS 2759.

3.1.3 Thermocouples: When load thermocouples are required, they shall be sheath protected to prevent deterioration due to furnace atmospheres.

3.2 Pretreatment:

3.2.1 Hardening: Parts, where core hardening is specified, shall be heat treated in accordance with AMS 2759 or as specified by the cognizant engineer to the required core hardness prior to gaseous nitrocarburizing. Tempering for the specified core hardness shall be at a temperature not lower than 1075°F (579°C).

3.2.2 Surface Condition: Parts shall be clean and free of scale, oxide, entrapped sand, mold or core sand material, metal particles, oil, or grease prior to the nitrocarburizing process. Parts must be completely dry.

3.2.3 Stress Relief: Parts which have been machined or straightened before nitrocarburizing may be stress relieved prior to nitrocarburizing. The stress relieving temperature shall be in accordance with AMS 2759. Stress relieving shall be done at a temperature not less than 20°F (10°C) above the highest nitrocarburizing temperature to be used. Surfaces to be nitrocarburized shall be mechanically or chemically cleaned subsequent to stress relieving and prior to nitrocarburizing.

3.2.4 Selective Nitrocarburizing (Masking): If parts are not to be nitrocarburized all over, the surfaces not to be nitrocarburized shall be masked to prevent absorption of the surface hardening atmosphere. Masking may be accomplished by copper plating in accordance with AMS 2418, bronze plating in accordance with AMS 2429, or tin plating in accordance with AMS 2408. Alternatively, parts may be nitrided all over and the case machined off the surfaces not to be carbonitrided. Other maskants may be used if approved by the cognizant engineer.

3.3 Procedure:

3.3.1 Fixturing: Parts shall be racked and supported to prevent distortion at temperature and to ensure free atmosphere circulation and reaction with all surfaces during the nitrocarburizing process. Trays and fixtures shall not affect the temperature uniformity or gas circulation in the processing unit.

3.3.2 Process Cycles: The following are typical required processing cycles for the various materials:

TABLE I

Material	Time, hours		Temperature Set Points	
	minimum	maximum	°F	°C
Carbon Steel	1	3	1060	571
Low-Alloy Steel	1	3	1060	571
Tool Steel (Structural)	0.5	3	1025	552
Tool Steel (Cutting)	0.1	2	1000	538
Cast Iron-Ductile, Malleable, or Gray	1	6	1060	571

3.3.3 Quenching: Following treatment, parts may be quenched in oil, water, soluble oil solutions, synthetic quenchants, inert or nitrocarburizing atmospheres, or air (See 8.1).

3.4 Properties: Gaseous nitrocarburized parts shall conform to the following requirements, determined on parts or on test specimens as in 4.3.1.

- 3.4.1 Depth of Compound Layers: Shall be as follows, determined in accordance with the taper or step grind procedure of SAE J423 or ARP1820 microscopic methods, at not less than 500x magnification.

Material	Compound Layer Thickness	
	Inch	Millimetres
Carbon Steel	0.00015 - 0.0010	0.0038 - 0.025
Low Alloy Steel	0.00015 - 0.0010	0.0038 - 0.025
Tool Steel (Structural)	0.0001 - 0.0005	0.0025 - 0.012
Tool Steel (Cutting)	-- 0.0002	-- 0.005
Cast Iron	0.00015 - 0.0010	0.0038 - 0.025

- 3.4.2 Test for Compound Layer Presence: Parts or samples shall be tested for the presence of a continuous compound layer using a copper sulfate solution composed of the following:

40 g copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$)
 1000 mL water
 5 mL wetting agent
 pH level 3.9 - 4.1

- 3.4.2.1 Apply the solution to a cleaned area with a swab and let stand for 30 seconds. Copper will not plate on surfaces with a continuous compound layer. If copper color appears in 30 seconds or less, no compound layer is present.
- 3.4.3 Compound Layer: Any surface porosity present shall not exceed one-half the observed depth of compound layer, determined as in 3.4.1.
- 3.4.4 Case Hardness: Shall be as follows, determined by microhardness measurements, at a depth of 0.002 inch (0.05 mm) from the treated surface, in accordance of ASTM E384 or by the chordal method of ARP1820 on prepared cross-sections of the nitrocarburized case using Knoop or other appropriate hardness tester, as agreed upon by the cognizant engineer.

Material	Hardness, minimum HK100, or equivalent
Carbon Steels	300
Low Alloy Steels	460
Tool & Die (Structural)	600
Tool & Die (Cutting)	700
Cast Iron (Gray Ductile or Malleable)	300

4. QUALITY ASSURANCE PROVISIONS:

- 4.1 Responsibility for Inspection: The purchaser of the treated parts shall supply all necessary test coupons; the vendor shall be responsible for performing all required tests. Results of such tests shall be reported to the purchaser as required by 4.5. 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 to determine conformance to requirements for compound layer depth (3.4.1), compound presence (3.4.2), and case hardness (3.4.4) are classified as acceptance tests and shall be performed on each lot.

4.2.2 Preproduction Tests: Tests to determine conformance to all technical requirements of this specification are classified as preproduction tests and shall be performed prior to or on the first-article shipment of a part 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.

4.2.2.1 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: Sufficient parts or test coupons of the same alloy, surface condition, and pretreatment shall be processed with each furnace load to permit duplicate conformation tests for each acceptance requirement; the exact number of parts or test coupons shall be established by purchaser. A lot shall be all parts of the same part number processed in the same furnace load.

4.4 Approval:

4.4.1 Sample parts shall be approved by purchaser before parts for production use are supplied, unless such approval be waived by purchaser.

4.4.2 Vendor shall use manufacturing procedures, processes, and methods of inspection on production parts which are essentially the same as those used on the approved sample parts. If necessary to make any change in established limits of the case or nitrocarburizing procedures, vendor shall submit for reapproval a statement of the revised operations and, when requested, sample nitrocarburized parts or test coupons. Production parts nitrocarburized by the revised procedure shall not be shipped prior to receipt of reapproval.

4.5 Reports: The vendor of nitrocarburized parts shall furnish with each shipment a report showing the results of tests to determine conformance to the acceptance test requirements. This report shall include the purchase order number, lot number, AMS 2757, contractor or other direct supplier of parts, part number, and quantity.

4.6 Resampling and Retesting: If any specimen used in the above tests fails to meet the specified requirements, disposition of the parts may be based on the results of testing three additional specimens for each original nonconforming specimen. Failure of any retest specimen to meet the specified requirements shall be cause for rejection of the parts represented and no additional testing shall be permitted. Results of all tests shall be reported.