AEROSPACE MATERIAL SPECIFICATION

AMS2759™/13	REV. A

Issued 2018-06
Revised 2025-04

Superseding AMS2759/13

(R) Gaseous Nitrocarburizing

RATIONALE

AMS2759/13A results from a Five-Year Review and update of this specification resulting in a complete revision.

NOTICE

ORDERING INFORMATION: In addition to that listed in AMS2759, the purchaser shall supply the following information to the heat-treating processor:

- AMS2759/13A
- Complete requirements for the part and processing if the engineering drawing is not provided
- Part material designation
- Heat-treat condition of parts to be processed
- Areas to be nitrocarburized, areas to be masked, and areas that are optional (see 3.2.4)
- Required compound zone thickness (see 3.5.5)
- Surface hardness, if required (see 3.5.1)
- Case hardness (see 3.5.2)
- Core hardness, if required (see 3.5.3)
- Case depth, if required (see 3.5.4)
- If parts are to be used for testing (see 4.2)

1. SCOPE

1.1 Purpose

This specification covers the engineering requirements for producing a continuous compound zone (white layer) on parts by means of a gaseous, low-temperature, carbon-enriched nitriding process.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/AMS2759/13A/

1.1.1 If the compound zone (white layer) is intended to be controlled automatically, AMS2759/12 should be used.

1.2 Application

The nitrocarburizing process described herein is used typically for enhancement of wear resistance and fatigue strength, as well as corrosion resistance in ferrous alloys, but usage is not limited to such applications.

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 that may be involved in such use. It is the 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.

1.4 Authority

The cognizant engineering organization may impose requirements or approve allowances that supersede the requirements in this AMS.

2. APPLICABLE DOCUMENTS

In addition to those listed in AMS2759, the issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The processor may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2408	Plating, Tin
AMS2418	Plating, Copper
AMS2429	Plating, Bronze, Nitriding Stop-off, 90Cu - 10Sn
AMS2750	Pyrometry
AMS2759	Heat Treatment of Steel Parts, General Requirements
AMS2759/1	Heat Treatment of Carbon and Low-Alloy Steel Parts, Minimum Tensile Strength Below 220 ksi (1517 MPa)
AMS2759/2	Heat Treatment of Low-Alloy Steel Parts, Minimum Tensile Strength 220 ksi (1517 MPa) and Higher
AMS2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
AMS2759/11	Stress Relief of Steel Parts
AMS2759/12	Automated Gaseous Nitrocarburizing, Controlled by Potentials
ARP1820	Chord Method of Evaluating Surface Microstructural Characteristics
AS7766	Terms Used in Aerospace Metals Specifications
SAE J423	Methods of Measuring Case Depth
SAE J864	Surface Hardness Testing with Files

2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E18 Rockwell Hardness of Metallic Materials

ASTM E140 Standard Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

ASTM E384 Microindentation Hardness of Materials

ASTM E407 Microetching Metals and Alloys

2.3 Definitions

Terms used in AMS2759/13 are defined in AMS2759, AS7766, and as follows:

2.3.1 COMPOUND ZONE

External, non-etching portion of nitrided layer, composed of compact epsilon or gamma prime nitrides or a combination thereof.

2.3.2 CORE HARDNESS

The hardness below the nitride case, as determined by a Knoop or a Vickers hardness traverse, where the average measured hardness does not change. A minimum of three hardness readings taken at a minimum distance of two times the case depth usually corresponds to this hardness. Core hardness readings can also be taken in accordance with ASTM E18.

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 AMS2759. Nitrocarburizing furnaces shall be Class 3 or better.

3.1.1 Furnace Controls

Shall be in accordance with AMS2750.

3.1.2 Thermocouples

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

3.2 Pre-Nitrocarburizing Operations

3.2.1 Heat Treatment

When heat treatment is specified for parts to be nitrocarburized, it shall be performed as specified prior to nitrocarburization. If a heat-treatment document is not called out, then it shall be performed in accordance with AMS2759 and to AMS2759/1 or AMS2759/2, as applicable.

3.2.2 Surface Condition

Parts shall be dry, clean, and free of scale, oxide, entrapped sand, mold or core sand material, metal particles, oil, or grease prior to the nitrocarburizing process. Cleaning shall be in accordance with AMS2759.

3.2.3 Stress Relief

Parts that have specified critical dimensions to be held through nitrocarburizing shall be stress relieved in accordance with AMS2759/11.

3.2.4 Masking

Part surfaces that are not to be nitrocarburized shall be masked.

3.2.4.1 Maskant Application

Masking may be accomplished by copper plating in accordance with AMS2418, bronze plating in accordance with AMS2429, or tin plating in accordance with AMS2408. Other maskants, such as stop-off paints, may be used if approved by the cognizant engineering organization. Copper plate shall be fine-grained and nonporous, not less than 0.001 inch (0.025 mm) in thickness. Bronze plate shall be not less than 0.0005-inch (0.0127-mm) thick.

3.2.4.2 Masking of Specimens

Test specimens, if used, shall be masked on a portion of the surface the same as the parts.

3.2.4.3 Alternative to Masking

When specified as an alternative to masking, the nitrocarburized case may be removed by mechanical or by chemical means from surfaces specified to be free from nitrocarburizing.

3.2.4.4 Inspection

Prior to nitrocarburizing, masking shall be visually inspected without magnification for blistering, peeling, or porosity. Parts with masking exhibiting these defects shall be rejected.

3.2.5 Racking

Rack or support parts to best prevent distortion and to ensure free circulation of the nitrocarburizing gas to all surfaces. If used, specimens are to be placed in the same working area of the furnace as the parts.

3.3 Nitrocarburizing

Processing shall be in accordance with AMS2759 and as follows:

3.3.1 Atmosphere

The nitrocarburizing atmosphere shall consist of a mixture of ammonia, a carbon-bearing gas, and a carrier gas. Acceptable carrier gases are endothermic, refined exothermic gas, and high-purity nitrogen; oxygen-bearing gas additions may be used for enrichment.

3.3.2 Cycle Times and Temperatures

Processing times and temperatures are shown in Table 1. Other times and temperatures may be used provided they meet all quality assurance requirements and are approved by the cognizant engineering organization. If prior heat treat is specified, the nitrocarburizing temperature shall not be higher than 50 °F (28 °C) below the final tempering or processing temperature unless the core hardness can be verified on an actual or representative part after processing.

Table 1 - Processing cycles

Material	Process Temperature Range °F	Process Temperature Range °C	Process Time Range Hours
Carbon Steel and Micro-Alloyed Steels	1000 to 1200	538 to 649	1 to 6
Low-Alloy Steel	950 to 1160	510 to 627	1 to 40
Tool Steel, Structural	930 to 1060	499 to 571	0.5 to 15
Tool Steel, Cutting	930 to 1025	499 to 552	0.1 to 15
Cast Iron (Ductile, Gray, and Malleable)	1010 to 1200	543 to 649	1 to 15

3.3.2.1 Preheating

Parts may be preheated in air to a temperature not higher than 850 °F (454 °C).

3.3.3 Cooling

Following treatment, parts may be quenched in oil, water, soluble oil solutions, aqueous polymer quenchants, inert or nitrocarburizing atmospheres, or air. A range of properties can be obtained by controlling the rate of cooling from the treatment temperature. Quenching method shall be determined by available equipment, preproduction testing, or as specified.

3.4 Post-Nitrocarburizing Operations

3.4.1 Inspection

Masking on parts shall be visually inspected without magnification for blistering, peeling, or porosity. Parts with masking exhibiting these defects shall be rejected.

3.4.2 Maskant Stripping

Maskant materials shall be removed by methods that do not cause embrittlement, pitting, or damage to the part.

3.4.3 Embrittlement Relief

Parts that have been pickled or etched in the course of plating removal after nitrocarburizing shall be baked to remove hydrogen in accordance with AMS2759/9.

3.5 Properties

3.5.1 Surface Hardness

When surface hardness is specified, the method of determination shall be agreed upon between the processor and the cognizant engineering organization. The method may include SAE J864 and/or ASTM E384.

3.5.2 Case Hardness in Diffusion Zone

Case hardness shall be measured in the diffusion zone in accordance with ASTM E384 or by the chord method of ARP1820, at a depth of 0.002 inch (0.05 mm) from the nitrocarburized surface on a mounted and polished cross section of the nitrocarburized case. A Knoop or Vickers indenter may be used, employing a test load of 0.2 kg. The minimum hardness shall meet the hardness stated in Table 2.

Table 2 - Diffusion zone case hardness minimum values

Material	Hardness HK100
Carbon Steel and Micro-Alloyed Steels	300
Low-Alloy Steels	460
Tool and Die Steels, Structural	600
Tool and Die Steels, Cutting	700
Cast Iron (Gray, Ductile, and Malleable)	300

3.5.3 Core Hardness

If specified, post-nitrocarburizing core hardness shall be the hardness at a minimum of two times the specified case depth. It shall be the average of at least three hardness readings taken in accordance with ASTM E384. Core hardness readings can also be taken in accordance with ASTM E18.

3.5.4 Case Depth

If specified, the case depth shall meet specified requirements. If the case depth is specified but does not specifically state that it is to be visual or total case depth, then total case depth, as defined below, shall apply.

3.5.4.1 Visual Case Depth

For carbon steels, case depth shall be determined visually, with the aid of a metallurgical microscope, as the distance from the surface to the depth at which needle-like nitride precipitates are still visible. When such precipitates are not visible, diffusion depth can be determined by application of etchants in addition to or in lieu of nital. On such steels, where “etched case depth” or “visual case depth” is specified, it shall be the distance measured from the surface in the direction of the core to the location where the needle zone or zone darkened by etching ends.

3.5.4.2 Total Case Depth

Total case depth shall be the depth below the surface at which the microindentation hardness is 50 HK or 50 HV higher than the core below the nitride case, as determined by a Knoop or a Vickers microhardness traverse, respectively. A minimum of three hardness readings taken at a minimum distance of two times the expected case depth shall be used to determine the core hardness below the case.

3.5.5 Thickness of Compound Zones

Thickness of compound zones shall conform to limits stated in Table 3, determined in accordance with SAE J423 or ARP1820 microscopic methods, at a minimum magnification of 500X.

Table 3 - Compound zone thickness

Material	Thickness Inches		Thickness Millimeters	
	Min	Max	Min	Max
Carbon Steel and Micro-Alloyed Steels	0.0002	0.0010	0.0051	0.025
Low-Alloy Steel	0.0002	0.0010	0.0051	0.025
Tool Steel, Structural	0.0001	0.0005	0.0025	0.013
Tool Steel, Cutting	0.0000	0.0002	0.0000	0.005
Cast Iron (Ductile, Gray, and Malleable)	0.0002	0.0010	0.0051	0.025

3.5.6 Porosity in Compound Zone

3.5.6.1 The upper half of the total compound thickness shall not contain more than 30% 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 15% for cast iron. A minimum of three fields of view shall be examined, at a minimum of 500X magnification.

3.5.6.2 Depth of porosity shall be measured as the distance between the surface and the end of the dense porous zone, as revealed by etching with 2% nital of a metallographically prepared surface as shown in Figure 1. The deeper situated “spikes” of porosity, jutting out in the direction of the core, formed by transformation of the ε nitride into γ’ nitride during cooling, shall not be taken into account.

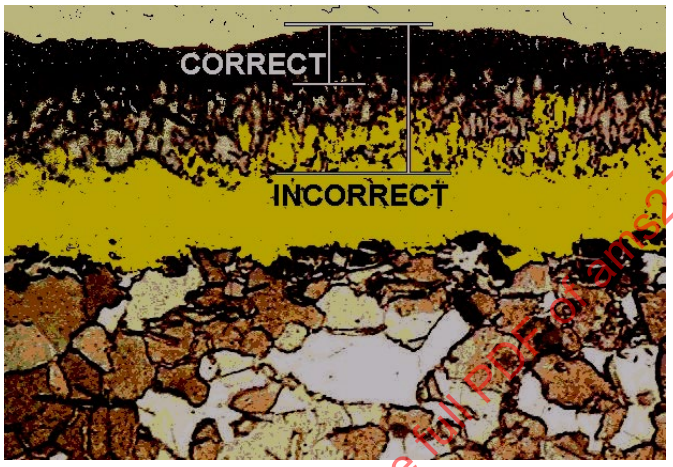

Figure 1 - Measurement of the depth of porosity

4. QUALITY ASSURANCE PROVISIONS

The responsibility for inspection, classification of tests, sampling and testing, approval, records, record retention, and report/certification shall be in accordance with AMS2759 and as follows:

4.1 Classification of Tests

4.1.1 Acceptance Tests

Surface hardness if specified (see 3.5.1), case hardness (see 3.5.2), core hardness if specified (see 3.5.3), case depth if specified (see 3.5.4), thickness of compound zone (see 3.5.5), and porosity in compound zone (see 3.5.6) are acceptance tests and shall be performed on specimens representing parts or on parts when specified from each lot.

4.1.2 Periodic Tests

Shall be in accordance with AMS2759.

4.1.3 Preproduction Tests

Shall be in accordance with AMS2759.

4.2 Sampling and Testing

Shall be in accordance with AMS2759 and as follows:

4.2.1 Specimens shall be provided by the purchaser. They shall have been made from the same material type and shall be in the same heat-treatment condition as the parts they represent. The processor shall process the specimens the same as the parts they represent. Parts shall be used for testing only when specified.