SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE MATERIAL SPECIFICATION

SAE AMS-S-6090

Issued APR 1998

Submitted for recognition as an American National Standard

Steel Carburizing and Nitriding, Processes for

NOTICE

This document has been taken directly from U.S. Military Specification MIL-S-6090A, Amendment 1, and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-S-6090A, Amendment 1. Any part numbers established by the original specification remain unchanged.

The original Military Specification was adopted as an SAE standard under the provisions of the SAE Technical Standards Board (TSB) Rules and Regulations (TSB 001) pertaining to accelerated adoption of government specifications and standards. TSB rules provide for (a) the publication of portions of unrevised government specifications and standards without consensus voting at the SAE Committee level, and (b) the use of the existing government specification or standard format.

Any material relating to qualified product lists has not been adopted by SAE. This material was part of the original military specification and is reprinted here for historic reference only.

1. SCOPE:

1.1 Processes:

This specification presents requirements for the carburizing and nitriding of carbon and alloy steels to produce the mechanical properties specified by drawings, detail metal specifications, or other applicable specifications (see 6.3).

1.1.1 The heat treatment of parts fabricated from the steels specified shall be in general accordance with the methods described in this specification, and in addition, shall be subject to such control and regulation by competent personnel as may be necessary to produce the properties required.

1.2 Equipment:

The equipment, methods, and processes used shall comply with this specification.

QUESTIONS REGARDING THIS DOCUMENT: (724) 772-7154 FAX: (724) 776-0243
TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS: http://www.sae.org

2. APPLICABLE DOCUMENTS:

The following publications, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

2.1 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-S-6709 Steel, Chrome-Molybdenum Aluminum; Bars, Rods, Billets, and Forging Stock (For Nitriding) (Aircraft Quality)
MIL-H-6875 Heat Treatment of Steels (Aircraft Practice, Process For)

2.2 SAE Publications:

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

AMS 2755 Nitriding, Molten Salt Bath
AMS 5643 Steel, Corrosion Resistant, Bars, Wire, Forgings, Tubing and Rings, 16Cr - 4.0Ni - 0.30Cb - 4.0Cu, Solution Heat Treated, Precipitation Hardenable
AMS 5659 Steel, Corrosion Resistant, Bars, Wire, Forgings, Rings, and Extrusions, 15Cr - 4.5Ni- 0.30Cb - 3.5Cu, Consumable Electrode Melted, Solution Heat Treated, Precipitation Hardenable
AMS 6475 Steel, Nitriding Grade, Bars, Forgings, and Tubing, 1.1Cr - 3.5Ni - 0.25Mo - 1.25Al (0.21 - 0.26C)
AMS 6485 Steel, Bars and Forgings, 5.0Cr - 1.3Mo - 0.50V (0.38-0.43C)

2.3 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E18 Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

3. EQUIPMENT:

3.1 Furnaces:

Furnace temperature control equipment, quenching and the handling equipment used in heat treatment shall comply with the requirements of Section 3 and paragraphs 6.1 and 6.2 of MIL-H-6875.

3.1.1 Furnaces used for carburizing shall not alternately be used for nitriding and vice versa. Furnaces used for nitriding shall not be used for other heat treating processes which may contaminate the furnace lining.

4. HEAT TREATMENT PROCEDURE:

4.1 Carburizing:

Carburizing is a process of adding carbon to the surface of steel by heating the parts in contact with suitable carbonaceous solids, liquids, or gases.

4.1.1 Any process which will give the required depth and hardness of case may be used. Carburizing and hardening temperatures for commonly used steels are specified in table I. Most carburizing is accomplished by gas carburizing, although salt bath carburizing is particularly effective for distortion control and for case depths less than .010. Pack carburizing is not permitted for aircraft or aerospace gears. Carburizing by this method is influenced by the compound time, and temperature at which the process is carried out. A low carbon carburizing steel will require approximately one hour at a gas carburizing temperature of 1650°F for a 1/64 inch deep effective case depth and approximately 5 hours for a 1/32 inch deep effective case depth. Higher carburizing temperatures will reduce the time.

4.1.2 The method of heat treatment of carburized parts depends on the chemical composition of the steel, its grain size, and the requirements for the parts.

4.1.2.1 Parts which are gas carburized should be cooled in a controlled atmosphere furnace to a temperature of 900*F, after which they may be air cooled. This treatment leaves the parts in a relatively soft condition and the treatment shown in column C or column E (or both) of table I is necessary to condition the parts for use.

4.1.3 Quenching: The parts may be quenched directly from the carburizing furnace thus producing a hard case and a core hardness within the range shown in column D, table I. This treatment produces a coarse grain in some types of steel and may cause excessive distortion of the parts. A fine grained steel usually shows less distortion that a coarse grained steel.

4.1.3.1 Core Treatment: The core treatment (column C, table I) refines the grain of the core and hardens both case and core. The core hardness is generally in the range given in column D.

TABLE I. Heat treatments for carburizing steels.

Steel SAE No.	Carburizing temperature °F (a)	Hardening for optimum case properties		Hardening for maximum case hardness	
		Austenitizing temperature for core refinement °F (b)	Core Hardness Rockwell	Austenitizing temperature for case °F	Core Hardness Rockwell
1020	1650-1700	1575-1625	C30-36	1375-1425(c)	B67
4615	1650-1700	1475-1525	C27-43	1425-1475(b)	B95
4620	1650-1700	1475-1525	C34-48	1425-1475(b)	C23
8620	1650-1700	1550-1600	C34-48	1350-1400(b)	C31
9310	1600-1700	1475-1525	C33-41	1350-1400(b)	B95

(a) Carburize to desired depth. Cool in furnace or quench in oil.
(b) Quench in oil maintained at temperature not higher than 150°F.
(c) Quench in water or brine.

4.1.3.2 Case Treatment: The case treatment (column E, Table I) refines the grain of the case and hardens it. The approximate core hardness after this treatment is shown in column F, table I. This treatment should be omitted in cases when a higher core strength is desired.

4.1.3.3 All carburized parts shall be tempered or stress relieved at a temperature not less than 250°F.

4.1.4 Cyanide hardening: The cyanide hardening operation produces a file hard, shallow, and brittle case on low carbon steels. The parts are usually immersed for 30 to 60 minutes in a bath containing sodium cyanide and operating at a temperature of 1400 to 1650°F. This operation will give a case depth approximately 0.010 inch with a hardness about Rc-65 and a negligible dimensional change is caused.

4.2 Nitriding:

Nitriding is a process of surface hardening steel by the formation of nitrides. The use of nitriding is normally limited to steels of selected alloy composition. Commonly nitrided steels include those specified in MIL-S-6709, AMS 6475, AMS 5659, AMS 5643 and AMS 6485. Other alloys such as 4140, 4340 and A286 may be nitrided to provide higher strength and moderate hardness.

4.2.1 Pre-treatment: The pre-treatment of parts to be nitrided shall be in accordance with the engineering drawing. Normally this includes hardening and tempering to develop the desired core properties to improve nitriding response, and to provide dimensional stability.

4.2.2 Surface: Surfaces to be nitrided shall be clean and free of decarburization and all foreign materials.

4.2.3 Process: Nitriding is generally accomplished by subjecting the parts to the action of dissociated ammonia gas at a temperature of 925 to 1050°F. The percent dissociation of ammonia, temperature, and time shall be as necessary to develop the specified nitrided case properties and minimizing the resultant white surface layer of high concentration of nitrides. The double-stage nitriding process may be used to minimize the thickness of the white layer. Its application is limited primarily to the aluminum-containing steels.

4.2.4 Liquid (molten salt bath): The liquid (molten salt bath) nitriding employs the same temperature range as gas nitriding. The ratio of cyanide to cynate must be controlled to insure proper nitriding. Liquid pressure nitriding may be used employing a flow of anhydrous ammonia through the molten bath which is sealed and maintained under a pressure of 1 to 30 psi.

4.2.4.1 Aerated bath: The aerated bath nitriding in accordance with AMS 2755 provides a nitrided case which is relatively soft, shallow, and ductile for specific applications. Parts nitrided by the aerated bath process are machined to final dimensions before being nitrided.

4.3 All other heat-treating operations required shall be in accordance with MIL-H-6875.

4.4 Case depth:

The case depth of the finished parts shall conform to the requirements specified on the engineering drawing.

4.5 Hardness:

The hardness of the material when tested on the designated area shall be as follows:

Case - Rockwell Superficial 15N, 90 minimum
Core - Rockwell C, 35 maximum

5. QUALITY ASSURANCE PROVISIONS:

5.1 Responsibility for inspection:

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements specified herein. Unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.