

MIL-S-6090A
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 SUPERSEDING
 MIL-S-6090
 31 March 1950

MILITARY SPECIFICATION

STEELS USED IN AIRCRAFT CARBURIZING AND NITRIDING, PROCESS FOR

This specification is mandatory for use by all Departments and Agencies of the Department of Defense.

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.

2. APPLICABLE DOCUMENTS

2.1 The following documents 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:

SPECIFICATIONS

Military

| | |
|------------|---|
| 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) |

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MIL-S-6090A

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

- * 2.2 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

E-18 Methods of Test for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.

(Applications for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103.)

3. EQUIPMENT

- * 3.1 Furnaces. The furnaces shall be of a suitable type and design for the intended purpose and shall be capable of maintaining within the working zone, with suitable pyrometric control. A temperature varying not more than $\pm 25^{\circ}\text{F}$ from the desired value. Suitable controlled atmospheres shall be provided for furnaces used for gas carburizing or nitriding.

3.2 Pyrometers. Pyrometers shall be of the automatic controlling and recording type and preferably of the potentiometer type. Thermocouples shall be placed in suitable protecting tubes, unless the furnace atmosphere is such that undue deterioration of the thermocouple will not result.

3.2.1 Pyrometers shall be checked at regular intervals of not more than three months, and upon the request of the inspector, by use of a separate thermocouple and indicator or recorder of the potentiometer type, which equipment has been calibrated against a standard. The check shall be made at the normal working temperature and with a normal change in the furnace.

MIL-S-6090A

3.3 Quenching tanks. The quenching tanks shall be of sufficient size to accommodate the work involved and shall provide for adequate circulation and control of the quenching medium.

3.4 Miscellaneous equipment. Suitable jigs, handling equipment and other accessories, shall be provided as necessary for the proper handling of the work and for maintenance of the major items of equipment.

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. Selective case hardening of parts is permissible and may be effected either by machining away the carburized surfaces or by using copper plating which will prevent carburization. Data contained in table I, is primarily for articles which are carburized by packing in a carburizing medium in a closed container. Carburizing by this method is influenced by the packing compound, time, and temperature at which the process is carried out. A low carbon carburizing steel will require approximately three hours at a carburizing temperature of 1650°F. For each 1/64 inch depth of case required. Higher carburizing temperatures will reduce the time. The best practice is to check the depth of case by examining the fracture of a test piece from the carburizing box. A wire attached to the specimen with one end exposed permits pulling and checking without cooling the container.

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 pack carburized or gas carburized may be cooled in the box or furnace to a temperature of about 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 type of steel and may cause excessive distortion of the parts. A fine grained steel usually shows less distortion than 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.

MIL-S-6090A

Table I. Heat treatments for carburizing steels.

| Column A | Column B | Column C | Column D | Column E | Column F |
|------------------|---|---|---|--|------------------------------|
| Steel SAE No. | Carburizing Temperature Degrees F. (a) | Quenching Temperature For Core Refinement Degrees F. (b) | Resulting Core Hardness Rockwell | Quenching Temperature For Case Degrees F. | Core Hardness Rockwell |
| 1020 | 1650-1700 | 1575-1625 | C 30-36 | 1375-1425 ^(c) | B 67 |
| 4615 | 1650-1700 | 1475-1525 | C 27-43 | 1425-1475 ^(b) | B 95 |
| 4620 | 1650-1700 | 1475-1525 | C 34-48 | 1425-1475 ^(b) | C 23 |
| NE8620 | 1650-1700 | 1550-1600 | C 34-48 | 1350-1400 ^(b) | C 31 |
| 9310 | 1600-1700 | 1450-1525 | C 35-42 | 1450-1525 ^(b) | - - |

(a) Carburize to desired depth. Cool in furnace or quench in oil.

(b) Quench in oil.

(c) Quench in water or brine.

(d) All carburized parts shall be drawn at a temperature between 250 and 350^oF to remove quenching strains.

* 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 drawn such that quenching strains are relieved and the desired hardness level obtained.

4.2 Nitriding. Nitriding is a process of surface hardening steel by subjecting the parts to the action of cracked ammonia gas to a temperature of 940 to 980^oF. Chromium-molybdenum-aluminum steel, in accordance with class 1, MIL-S-6709, is generally used for aircraft parts.

MIL-S-6090A

This steel shall be heat-treated and machined prior to nitriding. This steel shall be hardened by heating to a temperature of 1700 to 1750^oF and quenching in oil. Parts shall be drawn for a period of three to five hours after quenching. A drawing temperature of 1200^oF gives a tensile strength of approximately 125,000 pounds per square inch. Parts shall then be machined removing at least 1/32 inch of stock from all surfaces to remove scale and decarburized metal. The nitriding operation shall be carried out in specially constructed furnaces through which ammonia gas is circulated. The temperature shall be 940 to 980^oF. The parts shall be cooled in the furnace at the conclusion of the nitriding process and have a hard surface without further treatment. A 50 hour nitriding treatment produces a case approximately 0.020 inch thick having a surface hardness of about 1000 Vickers.

4.3 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^oF. This operation will give a case depth approximately 0.010 inch with a hardness about Rc-65 and a negligible dimensional change is caused.

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

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

* 4.6 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.

MIL-S-6090A

5.2 Method of inspection and tests.

5.2.1 The heat-treating equipment, temperature control devices, and all details of the heat-treating procedure shall be subject to inspection by authorized government inspectors.

5.2.2 Acceptance or approval of material during course of manufacture shall in no case be constructed as a guarantee of the acceptance of the finished product.

5.2.3 Test. When practicable, tests shall be made on actual parts. If tests of actual parts are impracticable, extra samples of the material shall be provided. Samples shall be heat-treated with the parts they represent, and unless otherwise specified, shall be of approximately the same cross sectional area and shape.

- * 5.2.3.1 Case depth. The sample shall be examined for compliance with 4.5.
- * 5.2.3.2 Case hardness. Case hardness tests shall be made in accordance with ASTM E-18 and in compliance with 4.6, or equivalent shall be used.
- * 5.2.3.3 Core hardness. Core hardness tests shall be made in accordance with ASTM E-18 to determine compliance with 4.6.
- * 5.3 Rejection and retest. Failure of a specimen to meet specified requirements shall cause rejection of the materials represented. At the discretion of the contractor retest will be permitted. A retest sample of five specimens, one from each of five bars, shall be tested to replace each failed specimen from the original sample. If one of the retest specimens fail, the material represented shall be rejected and no further retesting permitted.

6. NOTES

- * 6.1 Intended use. This specification is drawn to present general instructions for carburizing and nitriding of carbon and alloy steels and cyanide hardening operation used in the fabrication of aircraft and aircraft engine parts. Presents general requirements for acceptable heat-treating equipment. The particular steels to which this specification applies are listed in table I under their commercial designation .

6.1.2 Drawings. All drawings for heat-treated parts fabricated from the materials referenced herein shall contain the following information:

- a. Specification number.
- b. Heat-treating process.
- c. Case hardness (minimum acceptable) and required depth of case.
- d. Core properties required (elongation, tensile strength or hardness range, yield strength, et cetera).

* 6.3 This specification is applicable to bar steels covered by MIL-S-7393, MIL-S-6709, and MIL-S-8690; carburizing steels covered by MIL-S-7493 and MIL-S-83030.

6.4 Marginal indicia. Asterisks are used in this revision to identify changes (additions, deletions) with respect to the previous issue.

Custodians:

Army - MR
Navy - AS
Air Force - 11

Preparing activity:

Air Force - 11

Project Nr.: MISC-0766

Review activities:

Army - MR
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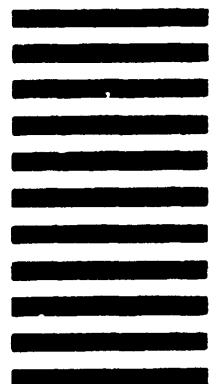
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