



AEROSPACE MATERIAL SPECIFICATION

AMS2769™

REV. D

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Revised 2020-09

Superseding AMS2769C

Heat Treatment of Parts in a Vacuum

RATIONALE

AMS2769D results from making changes to frequency (3.2.3.2), load sensors (3.5.3.2), load sensors (3.5.3.3.2), load sensors (3.5.3.4), and vacuum atmosphere system purging (A.3.1). These changes were made to clarify the intent of the requirements.

1. SCOPE

1.1 Purpose

This specification establishes the requirements and procedures for heat treating parts in vacuum/partial pressure and shall be used as a supplementary document to primary heat treating specifications as applicable.

1.2 Application

This process has been used typically for the heat treatment of carbon and alloy steels, tool steels, corrosion-resistant steels, precipitation-hardening steels, super alloys, titanium, and other nonferrous alloys, but usage is not limited to such applications.

1.2.1 Heat treatment as used in this specification includes solution treatment, homogenizing, austenitizing, annealing, normalizing, hardening, tempering, aging, and stress relieving. This specification does not cover processes such as melting, brazing, diffusion bonding, coating, carburizing, or nitriding.

1.2.2 The objective of this process is to produce heat treated parts that have minimal surface contamination and alloy depletion.

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.

1.4 The provisions of this specification revision shall become effective 90 days after publication.

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2. APPLICABLE DOCUMENTS

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 supplier 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.

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
AMS2759/3	Heat Treatment, Precipitation-Hardening Corrosion-Resistant, Maraging, and Secondary Hardening Steel Parts
AMS2759/4	Heat Treatment, Austenitic Corrosion-Resistant Steel Parts
AMS2759/5	Heat Treatment, Martensitic Corrosion-Resistant Steel Parts
AMS2773	Heat Treatment, Cast Nickel Alloy and Cobalt Alloy Parts
AMS2774	Heat Treatment, Wrought Nickel Alloy and Cobalt Alloy Parts
AMS2801	Heat Treatment of Titanium Alloy Parts
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications

2.2 CGA Publications

Available from Compressed Gas Association, Inc., 4221 Walney Road, 5th Floor, Chantilly, VA 20151-2923, Tel: 703-788-2700, www.cganet.com.

CGA G-5.3	Commodity Specification for Hydrogen
CGA G-9.1	Commodity Specification for Helium
CGA G-10.1	Commodity Specification for Nitrogen
CGA G-11.1	Commodity Specification for Argon

3. TECHNICAL REQUIREMENTS

3.1 Pyrometry

Shall be in accordance with AMS2750.

3.1.1 Control Sensors

Furnace control sensors shall be suitably protected and be of a type compatible with the range of temperatures and vacuum conditions used.

- 3.1.1.1 The types shown in Table 1 shall not be used unprotected (bare wire, i.e., other than protective sheathed) above the temperatures shown in Table 1.
- 3.1.1.2 Use of other sensor types shall be approved by the cognizant engineering organization.
- 3.1.1.3 When used in metal or other sheaths, care shall be taken to ensure that chemical reaction will not occur between the sheath and the sensor wire.

Table 1 - Bare control sensor types versus maximum operating temperature

Type	Maximum Temperature °F	Maximum Temperature °C
K (Chromel-Alumel) ⁽¹⁾	2200	1204
N (Nicrosil-Nisil) ⁽¹⁾	2200	1204
Nickel-Nickel/Molybdenum	2300	1260
S,R (Platinum-Platinum/Rhodium)	2600	1427
B (Platinum/Rhodium-Platinum/Rhodium)	3100	1704
Tungsten-Tungsten/Rhenium	4000	2204

NOTES:

⁽¹⁾ Re-use of thermocouples shall comply with the current revision of AMS2750.

3.2 Furnace Equipment

The equipment shall conform to the requirements of the applicable heat treat specifications. The furnace components shall result in no detrimental metallurgical effects on the material processed during a normal production run as a result of vaporization or chemical reaction between the furnace components and the gases used to maintain partial pressure in the furnace.

3.2.1 Types of Vacuum Furnaces

Appendix A specifies exemptions and additions to this specification for the use of multi-cell vacuum furnaces as described below.

3.2.1.1 Single Chamber Furnace

A single chamber furnace is a furnace that has only one vacuum chamber and that only performs a single heat treatment process at a time. Appendix A shall not apply.

3.2.1.2 Multi-Chamber Furnace

A multi-chamber furnace is a furnace that has multiple chambers that may or may not be separated by vacuum sealed doors and that only performs a single heat treatment process at a time. Appendix A shall not apply.

3.2.1.3 Multi-Cell Furnace

A multi-cell furnace has one or more vacuum systems with multiple cells that can perform multiple heat treatment processes simultaneously. Appendix A shall apply.

3.2.2 Vacuum System

The vacuum pumping system shall have sufficient pumping capacity to evacuate the furnace to a pressure indicated in Table 2 for the materials being processed. It shall also maintain the desired level of vacuum during the soak time, and the entire heat treating process except for instances of outgassing that may occur during the heat up cycle, as referenced in 3.5.2.1. When processing using partial pressure, the furnace shall first be pumped down to a pressure of 100 microns or lower prior to heating.

- 3.2.2.1 Diffusion pumps shall be isolated from the main vacuum chamber to prevent back-streaming at chamber pressures above those recommended by the manufacturer of the furnace, pump, and/or pump oil which are typically below 100 microns.
- 3.2.2.2 Parts made of carbon and alloy steel, corrosion resistant steel, or tool steel may be processed in a furnace not operating within Table 2 vacuum operating ranges, provided the parts meet the surface contamination requirements in the applicable heat treatment specification. All other requirements of this specification shall be met.

Table 2 - Vacuum range as a function of processing temperature range for various alloys

Material	Processing Range °F	Processing Range °C	Operating Range Microns ⁽⁶⁾⁽⁷⁾⁽⁸⁾
Carbon and Alloy Steels ⁽⁹⁾	1000 to 1800	538 to 982	1 to 500 ⁽¹⁾
Corrosion-Resistant Steels ⁽⁹⁾			
Ferritic (12 to 17% Cr)	1200 to 1650	649 to 899	1 to 500 ⁽¹⁾
Martensitic	1200 to 2050	649 to 1121	1 to 500 ⁽¹⁾
Austenitic	1750 to 2050	954 to 1121	1 to 500 ⁽¹⁾
Precipitation Hardening Steels ⁽⁹⁾	850 to 2150	454 to 1177	1 to 500 ⁽¹⁾⁽³⁾
Superalloys			
Nickel Alloys	1150 to 2275	621 to 1246	<10
Cobalt Alloys	1350 to 2250	732 to 1232	<10
Iron Alloys	1600 to 2150	871 to 1177	<500 ⁽²⁾⁽³⁾
Tool Steels ⁽⁹⁾			
Air Hardening	1470 to 1850	799 to 1010	0.1 to 500 ⁽¹⁾
Cold Work	1470 to 1950	799 to 1066	0.1 to 500 ⁽¹⁾
Hot Work	1470 to 1900	799 to 1038	0.1 to 500 ⁽¹⁾
High Speed (M Series)	1470 to 2250	799 to 1232	0.1 to 500 ⁽¹⁾
High Speed (T Series)	1550 to 2375	843 to 1302	0.1 to 500 ⁽¹⁾
Titanium and Titanium Alloys	1300 and below Above 1300	704 and below Above 704	<1 ⁽⁴⁾ <0.1 ⁽⁴⁾
Copper Alloys ⁽⁵⁾	Below 1000 1000 to 2100	Below 538 538 to 1149	10 to 500 150 to 500

NOTES:

- (1) For pressures higher than 100 microns, partial pressures of approved gases are required (see 3.3.1.1).
- (2) For pressures higher than 20 microns, partial pressures of approved gases are required (see 3.3.1.1).
- (3) Nitrogen not permitted as a partial pressure gas above 1400 °F (760 °C).
- (4) Hydrogen not permitted as a partial pressure or quench gas.
- (5) Alloys containing zinc - not recommended.
- (6) For clarity, the single vacuum term "micron" is used. See 8.2.3 for relation to other values commonly used.
- (7) The pressures specified apply to vacuum furnaces not equipped for atmosphere circulation.
- (8) For furnaces equipped with atmosphere circulation, partial pressures higher than those indicated may be used at temperatures below 1000 °F (538 °C).
- (9) At temperatures 2100 °F (1149 °C) and below, minimum pressure may be 1/10 of the value shown.

3.2.3 Vacuum Sensing Equipment

The vacuum furnace shall be equipped with at least one gauge capable of sensing and recording the pressure in the vacuum heating chamber of the furnace at any point within the equipment operating temperature range required for the material and processing being performed. Recommended gauges are shown in Table 3.

Table 3 - Vacuum level versus recommended gauge

Vacuum Level	Gauge
10 ⁻⁶ to 1 micron	Hot filament ionization
10 ⁻⁴ to 10 microns	Cold cathode ionization
1 to 10 ³ microns	Thermocouple or Pirani