



AEROSPACE MATERIAL SPECIFICATION

AMS2801™**REV. D**

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Superseding AMS2801C

Heat Treatment of Titanium Alloy Parts

RATIONALE

AMS2801D is a limited revision which revises the racking requirement for fasteners and small parts (see 3.3.2.2) and adds a new Table 7 to allow higher processing temperature for Beta alloys with related changes to Hydrogen Pick-Up (see 3.4.1) and Surface Contamination (see 3.4.2) provisions. Subsequent table numbers have been revised based on the addition of Table 7.

NOTICE

ORDERING INFORMATION: The following information shall be provided to the heat-treating processor by the purchaser.

1. Purchase order and/or purchaser supplied documents shall specify not less than the following:

- AMS2801D
- Quantity of parts
- Size of parts
- Part number
- Material alloy designation of parts
 - Including mill heat/lot number, if applicable
 - Beta transus temperature, if it is required to be known for processing
- Heat-treat operations required, including:
 - Heat-treat condition, as delivered
 - Heat-treatment condition required
 - Tensile requirement, if applicable
 - Minimum stock removal after heat treatment

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Full document details: SAE AMS2801D

For more information on this standard, visit
<https://www.sae.org/standards/content/AMS2801D>

Documents

Document Sharing Hub

- Processing variables not defined or different from the specification
 - Processing temperatures, times, and other parameters
 - Allowance for straightening
 - Post straightening thermal operations requirements
 - Pre-cleaning and post-cleaning requirements
 - Post heat-treatment protection requirements
 - Any restriction to options allowed within this specification
- If removal of surface contamination after heat treatment is to be performed by the heat-treatment processor (see 3.3.4)
- Surface contamination removal method and parameters, if it is to be performed by the heat-treatment processor
- Additional ordering information as required

1. SCOPE

1.1 Purpose

This specification establishes the engineering requirements for the heat treatment of titanium and titanium alloy parts. Heat treatment of raw material by raw material producers, forge shops, or foundries shall be in accordance with the material procurement specification AMS-H-81200.

1.2 Heat Treatments

Heat treatments covered by this specification are stated in Table 1.

Table 1 - Applicable heat treatments

Anneal	Beta Solution Treated and Overaged
Stress Relief	Solution Treat
Age	Beta Solution Treat
Overage	Solution Treat and Age
Cold Worked and Aged	Solution Treat and Over Age

1.3 Alloys

Titanium and titanium alloys are covered by this specification are stated in Table 2.

Table 2 - Titanium and titanium alloys

Commercially Pure	Alpha alloys	Alpha-Beta alloys	Beta alloys
Ti40	5Al-2.5Sn	6Al-4V	13V-11Cr-3Al
Ti55	5Al-2.5Sn ELI	6Al-4V ELI	3Al-8V-6Cr-4Mo-4Zr
Ti70	6Al-2Cb-1Ta-0.8Mo	6Al-6V-2Sn	15V-3Al-3Cr-3Sn
	8Al-1Mo-1V	3Al-2.5V	10V-2Fe-3Al
		6Al-2Sn-4Zr-2Mo	
		6Al-2Sn-4Zr-6Mo	

1.3.1 Other Alloys and Heat Treatments

This specification may be used for the heat treatment of parts made from alloys other than those in Table 2, provided that temperatures, times, and quenchants are specified by the cognizant engineering organization.

1.4 Processes Not Covered by This Specification

This specification does not cover selective heat treatments (induction, flame, laser, etc.) nor the use of thermal processing required to facilitate shaping or forming of titanium parts.

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
AMS2769	Heat Treatment of Parts in a Vacuum
AMS4901	Titanium Sheet, Strip, and Plate, Commercially Pure, Annealed, 70.0 ksi (485 MPa)
AMS-H-81200	Heat Treatment of Titanium and Titanium Alloys
AS7766	Terms Used in Aerospace Metals Specifications
ARP1962	Training and Approval of Heat-Treating Personnel

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 E3	Preparation of Metallographic Specimens
ASTM E8/E8M	Tension Testing of Metallic Materials
ASTM E407	Microetching Metals and Alloys
ASTM E1447	Determination of Hydrogen in Reactive Metals and Reactive Metal Alloys by Inert Gas Fusion with Detection by Thermal Conductivity or Infrared Spectrometry

2.3 CGA Publications (Compressed Gas Association)

Available from CGA, 14501 George Carter Way, Suite 103, Chantilly, VA 20151, Tel: 703-788-2700, www.cganet.com.

CGA G-9.1	Commodity Specification for Helium
CGA G-11.1	Commodity Specification for Argon

2.4 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein, the text of this document shall take precedence. Nothing in this document, however, shall supersede applicable laws and regulations, unless a specific exemption has been obtained.

2.5 Terms used in AMS are defined in AS7766.

2.5.1 Parts

Finished and semi-finished parts heat treated by the user during the fabrication process.

2.5.2 Thickness

The thickness is the minimum dimension of the heaviest section of the part.

3. TECHNICAL REQUIREMENTS

3.1 Pyrometry

Thermal processing equipment shall meet the requirements of AMS2750. Furnaces shall have a minimum of Type D instrumentation.

3.2 Furnace Equipment

All heating, quenching and other processing equipment used for thermal treating shall be capable of producing conforming parts.

3.2.1 Furnace classes are as defined in AMS2750.

3.2.1.1 Furnace classes for annealing, stress relieving, solution treating, or beta solution treating shall be Class 5 or better.

3.2.1.2 Furnace class for aging and overaging shall be Class 3 or better except as noted in 3.2.1.2.1.

3.2.1.2.1 The furnace shall be Class 2 or better for parts made from the following five alloys when the temperature is 1025 °F (552 °C) or lower: 6Al-6V-2Sn, 13V-11Cr-3Al, 15V-3Cr-3Al-3Sn, 10V-2Fe-3Al, and 3Al-8V-6Cr-4Mo-4Zr.

3.2.2 Atmospheres

Allowable environments during heat treatment are inert gases argon or helium, or mixtures thereof, vacuum, and air. When removal of surface contamination from the heat-treated part is not feasible, argon, helium, or mixtures thereof, or vacuum environment shall be used. Protective coatings may be used to avoid or minimize the detrimental effects of heating in air when approved by the cognizant engineering organization (see 3.3.4.2).

3.2.2.1 Inert Atmospheres

Argon equivalent or having greater purity than CGA G-11.1, Grade C, or helium equivalent or having greater purity than CGA G-9.1, Grade L, shall be circulated within the furnace as necessary to protect all surfaces of the parts. The gas dew point when measured at the gas inlet of the furnace shall be -60 °F (-51 °C) or lower. Furnace ducts and zones containing parts shall be sealed as to prevent contamination of any parts to the degree that they are rendered nonconforming to specified material requirements.

3.2.2.2 Vacuum

3.2.2.2.1 Vacuum furnaces and processing shall be in accordance with AMS2769.

3.2.2.2.2 Cooling may be accelerated by back-filling with inert gas conforming to 3.2.2.1.



3.2.2.3 Prohibited Atmospheres

Gas mixtures resulting from the combustion in air of hydrocarbons (gas or oil), endothermic, exothermic, hydrogen, and dissociated ammonia atmospheres are prohibited from being used during any heat-treatment operation.

3.2.3 Furnace Purging

Prior to heat treatment of parts, each furnace that has contained an atmosphere unacceptable for heat treating titanium and titanium alloys (see 3.2.2.3) shall be purged with air or inert gas, as applicable.

3.2.3.1 The volume of purging air or inert gas introduced shall be at least six times the volume of the furnace chamber. During purging, the minimum temperature within the chamber shall be the intended soaking temperature. When air or inert gas purging is impractical, the furnace temperature shall be set to a minimum of 200 °F (111 °C) above the intended soaking temperature and be held at that temperature for a minimum of 4 hours. Following purging or elevated temperature soak, the furnace shall be stabilized at the required temperature, loaded with a production load, and the load then heated and soaked, as applicable. Following heat treatment and any subsequent cleaning, pickling, or other process that may introduce hydrogen contamination, specimens shall be taken from the load and examined for conformance with hydrogen and surface contamination requirements of 3.4.1 and 3.4.2.

3.2.3.2 Purging Prior to Introducing Inert Gas

Unless otherwise specified, furnaces shall be loaded, purged with a volume of air or inert gas at least six times the volume of the furnace chamber, and subsequently filled with argon or helium. The load shall then be heated and soaked as applicable.

3.2.4 Auxiliary Equipment

Auxiliary equipment such as fixtures, jigs, hangers, trays, racks, belts, etc., shall be used, as necessary. This equipment shall not reduce the heating, cooling, or quenching rates below those required for proper heat treatment and shall not cause surface contamination of finished part surfaces. All auxiliary equipment contacting parts shall be made of heat-resistant metal such as stainless steel or nickel base alloys. Nickel bearing heat-resistant metals shall not be used in contact with finished part surfaces above 1700 °F (927 °C). The use of ceramic, carbon or other suitable nonreactive material is also permitted, with the requirement that the surface contamination specimen per 4.3.4 be excised at the contact point where the material contacts the nonreactive material.

3.2.5 Quenching Facilities and Media

All heat-treatable titanium alloys, except alloys that can be cooled at a rate of furnace cool, or air cool, or faster, shall be quenched by complete immersion in water, oil, or polymer, as applicable. Quenching and handling facilities shall be located such that contact between the quenchant, and parts occurs within the time required for compliance of Ti-6Al-4V and Ti-6Al-4V ELI alloy as specified in Table 3. For other alloys, quench delay times shall be as necessary to develop required properties. Use of molten salt baths for quenching is prohibited (see 8.9 and 8.10).

Table 3 - Quench delay time⁽¹⁾⁽²⁾

Nominal Thickness, Inches (mm)	Maximum Delay Time (Seconds)
Up to 0.25 (6.4), excl	6
0.25 (6.4) to 1.00 (25.4), excl	8
1.00 (25.4) to 3.00 (76.2), excl	10
3.00 (76.2) and over	30

⁽¹⁾ Quench delay time begins when the furnace door starts to open and ends when the last corner of the load is immersed in the quenchant. In bottom-quench air furnaces, the quench delay time starts when the parts emerge from the work zone or when the work zone temperature drops below the minimum solution temperature, whichever comes first.

⁽²⁾ Times shown apply to Ti-6Al-4V and Ti-6Al-4V ELI.