



AEROSPACE MATERIAL SPECIFICATION

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Superseding AMS-H-6875B

Heat Treatment of Steel Raw Materials

RATIONALE

AMS-H-6875C has been replaced by AMS2761.

STABILIZED NOTICE

AMS-H-6875C has been declared "STABILIZED" by AMS Committee E. This document will no longer be updated and may no longer represent standard industry practice. This document was stabilized because a four-digit replacement has been issued. Previously, this document was reaffirmed. The last technical update of this document occurred in November 2010. Users of this document should refer to the cognizant engineering organization for disposition of any issues with reports/certifications to this specification, including exceptions listed on the certification.

NOTE: In many cases, the purchaser may represent a sub-tier supplier and not the cognizant engineering organization.

AMS Committee E recommends that the following similar, but not identical, specification may be considered for future procurement. This listing does not constitute authority to substitute these specifications for the "STABILIZED" specification.

AMS2761 Heat Treatment of Steel Raw Materials

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Documents

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NOTICE

The initial SAE publication of this document was taken directly from U.S. Military Standard MIL-H-6875H, Amendment 2. This SAE Standard may retain the same part numbers established by the original military document. Any requirements associated with Qualified Products Lists (QPL) may continue to be mandatory for DoD contracts. Requirements relating to QPLs have not been adopted by the SAE for this standard and are not part of this SAE document.

1. SCOPE

1.1 Scope

This specification covers the requirements for heat-treatment of four classes of steel (See 1.2) and the requirements for furnace equipment, test procedures and information for heat-treating procedures, heat-treating temperatures and material (See 6.3) test procedures. This specification is applicable only to the heat treatment of raw material (See 6.3.1); it does not cover the requirements for the heat treatment of steel parts (See 3.4 and 6.3.2). This specification also describes procedures that, when followed, will produce the desired properties and material qualities within the limitations of the respective alloys tabulated in Tables 1A, 1B, 1C and 1D. Alloys other than those specifically covered herein may be heat treated using all applicable requirements of this specification.

1.1.1 Limitations

Unless otherwise specified, this specification is not applicable to heating or to intermediate (non-final) heat treatment, of raw material, e.g., for hot working. Processes not covered include deliberate surface heat-treating and specialized heat-treating, such as induction hardening, flame hardening, carburizing, nitriding; however, this specification may be referenced for equipment and controls. Austempering, ausbay quenching and martempering may be used when specified by the cognizant engineering organization.

1.2 Classification

Steels covered by this specification are classified into the following four classes. Unless otherwise specified, the process and equipment requirements in this specification refer to all classes of steel tabulated in Tables 1A, 1B, 1C, and 1D, respectively.

Class A - Carbon and low alloy steel

Class B - Martensitic corrosion-resistant steel

Class C - Austenitic corrosion-resistant steel

Class D - Precipitation-hardening and maraging steel

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 724-776-4970 (outside USA), www.sae.org.

AMS2418	Plating, Copper
AMS2424	Plating, Nickel, Low-Stressed Deposit
AMS2750	Pyrometry
AMS2759	Heat Treatment of Steel Parts, General Requirements
AMS2759/3	Heat Treatment, Precipitation-Hardening Corrosion-Resistant and Maraging Steel Parts
AMS-QQ-N-290	Nickel Plating (Electrodeposited)

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 A 262	Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels
ASTM A 370	Mechanical Testing of Steel Products
ASTM C 848	Young's Modulus, Shear Modulus, and Poisson's Ratio for Ceramic Whitewares by Resonance
ASTM D 3520	Quenching Time of Heat Treating Fluids (Magnetic Quenchometer Test)
ASTM E 3	Metallographic Specimens, Preparation of
ASTM E 8 / E 8M	Tension Testing of Metallic Materials

ASTM E 10	Brinell Hardness of Metallic Materials
ASTM E 18	Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E 384	Knoop and Vickers Hardness of Materials

3. REQUIREMENTS

3.1 Equipment

3.1.1 Furnace Media and Protective Coatings

3.1.1.1 Atmosphere for Classes A, B, C and D Steel Parts

The gaseous medium for heat treating Classes A, B, C and D steel parts above 1250 °F shall be air/products of combustion, argon, helium, hydrogen, nitrogen, or blends of these gases, vacuum, exothermic, endothermic, nitrogen based, or dissociated ammonia conforming to the requirements shown in Table 1. Supplementary protective coatings, in accordance with 3.3.1.3, may be used where necessary.

TABLE 1 - FURNACE ATMOSPHERE REQUIREMENTS

Atmosphere	Class A 1/	Class B 1/	Class C 1/	Class D 1/
Air/Products of Combustion	X 2/	X 2/	X	X
Argon 3/	X	X	X	X
Helium 3/	X	X	X	X
Hydrogen 3/	X	X 7/	X	X 5/
Nitrogen 3/ 6/	X 8/	X	X	X10/
Vacuum	X	X	X	X11/
Exothermic 4/	X	X	X	No
Nitrogen based or endothermic 4/	X 8/	X	No	No
Dissociated Ammonia 3/ 9/	No	No	X	No

1/ X - Denotes atmosphere acceptable for use on that designated class of steel with or without limitations.

2/ Unless otherwise specified, an air/product of combustion atmosphere shall be limited to precipitation hardening, tempering, stress relieving and 1400 °F transformation treatments. An air/product of combustion atmosphere may be used for treatment above 1400 °F for Classes A and B material that will have a minimum of 0.020 inch metal removed from all surfaces after heat treatment or that have been protected by electroplates.

3/ Dew point shall be not higher than -40 °F at the exit of the working zone.

4/ Atmosphere shall be refined or blended to avoid a change in carbon content at the surface of the material as specified in 3.3.3. A product of combustion at -40 °F maximum dew point (e.g., endothermic) may be used for class A material that allows 0.003 inch maximum partial decarburization at the surface. Exothermic atmosphere permissible only for heat treatment of class A mill products.

5/ Acceptable up to 1950 °F.

6/ Nitrogen atmosphere does not include nitrogen from dissociated ammonia

7/ Only acceptable when tempered at 1000 °F or above. Acceptable for annealing.

8/ Class A steels may be fine grain copper plated 0.002 to 0.005 inch thick in accordance with AMS2418 or nickel plated per AMS2424 or AMS-QQ-N-290 or equivalent as a supplementary surface protection. Other supplementary protective coatings may be used if approved by the cognizant engineering organization.

9/ Permissible only for annealing of mill products providing residual ammonia at the outlet of the generator does not exceed 15 ppm.

10/ The use of a nitrogen atmosphere shall be limited to heat treating temperatures of 1400 °F and below. A nitrogen atmosphere may be used for heat treatment above 1400 °F provided a minimum of 0.020 inches of metal is subsequently removed from all surfaces of heat treated material.

11/ Nitrogen is not permitted as a partial pressure above 1400 °F. Nitrogen may be used as a backfill quench for vacuum heat treatments performed at or below 1925 °F.

3.1.1.2 Atmospheres for Mill Products

Furnaces for mill products shall be supplied with gases of a consistent analysis such that the product meets the requirements of the appropriate material specification. Furnaces, gases, and gas generators shall be controlled. Ducts and working zones shall be sealed to prevent contamination by outside gases. Vacuum furnaces shall have a calibrated recording instrument for sensing the vacuum in the vacuum chamber. All atmosphere furnaces and gas supply lines shall be purged with the designated and approved atmosphere gas for the specific steel to be heat treated.

3.1.1.3 Salt Baths

Salt baths may be used for the heat treatment of Classes A and B steels. Salt baths shall be tested initially and at least once each week and shall be adjusted to assure that part surfaces shall be free from general corrosion, carburization and decarburization or intergranular attack in excess of limits specified in 3.3.3. Additives used for adjustments shall be limited to salts in bath and rectifiers recommended by the salt manufacturer.

3.1.1.4 Temperature Uniformity

The design and construction of heating equipment shall be such that the temperature at any point in the furnace working zone or work load shall comply with AMS2750.

3.1.1.5 Temperature Range and Set Temperature

The set temperature on the furnace control instrument shall be such that the load temperature falls within the specified range, taking into account the temperature uniformity of the furnace. In continuous furnaces used to anneal and normalize mill products, a thermal head may be used. The temperature of the mill product shall not exceed the maximum processing temperature.

3.1.2 Pyrometry and Furnace Temperature Control

The requirements and procedures for control and testing of furnaces, ovens, salt baths, vacuum furnaces, refrigeration equipment and allied pyrometric equipment used for heat treatment shall be in accordance with AMS2750.

- 3.1.2.1 All furnaces shall be instrumented to a minimum of Type D Instrumentation in accordance with AMS2750. Unless the material specification temperature tolerance or range requires a different furnace class or otherwise indicated herein, furnace class requirements per AMS2750 are shown in Figure 1:

FIGURE 1 - FURNACE CLASS REQUIREMENTS

AMS-H-6875 Process	AMS2750 Furnace Class
Tempering (after hardening) of - D6AC and 9Ni-4Co (Class A) alloy steels - other (Class A) low alloy steels - 220 ksi (1517 MPa) UTS and higher	Class 2 (± 10 °F/6 °C)
Aging of (Class D) PH stainless steels at 1025 °F (552 °C) and below	Class 2 (± 10 °F/6 °C)
Aging of (Class D) PH stainless steels above 1025 °F (552 °C)	Class 3 (± 15 °F/8 °C)
All Other Processes	Class 5 (± 25 °F/14 °C)

3.1.3 Quenching Equipment

3.1.3.1 Quench Baths

Quench baths shall permit complete immersion of material, provide for adequate circulation of the media or agitation of material, provide a means for indicating the temperature of the media and for cooling and heating, as applicable. Baths shall be adequate to produce the required properties in the most massive material to be quenched.

3.1.3.1.1 Oil-Quenching Baths

The oil-quenching medium shall be between 60 °F and 160 °F at the beginning of the quenching operation and shall not exceed 200 °F at any time during the quenching operation, unless otherwise approved by the cognizant engineering organization. The temperature of the oil quenching media shall not exceed the manufacturers recommended operating range. Quench oil used in integral quench vacuum furnace systems, where the quench chamber is below atmospheric pressure, shall be vacuum degassed at approximately the maximum recommended temperature for the quenchant initially and after each major addition of oil.

3.1.3.1.2 Aqueous Polymer Quenchants

Aqueous polymer quenchants may be used as permitted in Tables 1A through 1D. The temperature of the aqueous polymer quenchant baths shall not exceed the manufacturers recommended operating range. These baths shall also be adequately circulated to assure homogeneity of the aqueous polymer quenchant media.

3.1.3.1.3 Quenching from Salt Bath Furnaces

Water-quenching baths employed in cooling steel parts that have been heated in salt-bath furnaces should be provided with an inflow of fresh water to prevent a concentration of dissolved salts in the tanks. Polymer quenching baths when used in conjunction with salt bath furnaces shall be monitored weekly so that the salt content of the bath shall not exceed 6% by weight of the bath. All salt residues shall be removed from parts processed in salt-bath furnaces or quenched in brine, during or immediately following quenching.

3.1.3.1.4 Alternative Quenchants

In lieu of the stated methods in Tables 1A through 1D, steam, air, water sprays, inert gases, polymers, molten salts or other commercial quenching media or processes may be used when approved by the cognizant engineering organization, providing equivalence with respect to mechanical properties and corrosion resistance, as applicable to the material and its application, can be substantiated. Equivalence tests shall be as specified by the cognizant engineering organization. Where air quenching is permitted in Tables 1A through 1D, argon and helium may be used; other inert gases may be substituted when approved by the cognizant engineering organization.

3.1.3.2 Location of Quenching Equipment

Quenching equipment shall be located in such a manner and handling facilities shall function with sufficient speed to prevent the initiation of transformation or sensitization prior to quenching.

3.1.4 Miscellaneous Equipment

Suitable jigs, fixtures, trays, hangers, racks, ventilators, and so on, shall be employed as necessary for the proper handling of the work and for maintenance of the major items of equipment. The use of heat-treating fixtures or fixture materials where the contact with or proximity to the material could contaminate the material or reduce the heating, cooling or quenching rates to less than required for complete transformation or through-hardening of the material shall not be permitted.

3.1.5 Cleaning Equipment

Equipment shall be provided to clean material in accordance with 3.3.1.1. Where toxic or harmful cleaners are employed, they shall be used in compliance with the applicable health and safety regulations.

3.2 Thermal Treatment

3.2.1 Rate of heating

Heating rates shall be controlled to prevent damage to the material (See 6.4). Pre-heating at 1000 to 1200 °F is recommended before heating material above 1300 °F if the material:

Has been previously hardened above Rc 35, or is made of steel of 0.50 (nominal) percent carbon or over, or

Has abrupt changes of section, or sharp re-entrant angles, or

Has been finish machined.

3.2.2 Hardening of Classes A and B Material

Classes A and B material shall be hardened by austenitizing, quenching and tempering.

3.2.2.1 Prior Condition of Class A Steel Parts

3.2.2.1.1 H-11 Material

H-11 parts shall be in the annealed condition, prior to hardening, unless it has been hot headed. Hot headed H-11 material shall be annealed, prior to hardening, by furnace cooling from 1625 °F $\pm$ 25 to at least 1000 °F, at a maximum rate of 50 °F per hour.

3.2.2.1.2 52100 or 1095 Material

Parts made of 52100 or 1095 steel should be hardened from the spheroidize annealed condition.

3.2.2.1.3 Other Class A Parts

Parts made from other Class A steels to be hardened and tempered to 220 ksi and above shall be either normalized, normalized and tempered, or normalized and sub-critical annealed, prior to initial austenitizing. Parts that have been welded shall be normalized, prior to hardening. Parts identified as damage tolerant, maintenance critical or fracture critical shall be normalized, normalized and tempered or normalized and subcritical annealed, regardless of the strength that they are subsequently to be heat-treated.

3.2.2.2 Austenitizing

The austenitizing temperature shall conform to Tables 1A and 1B, as applicable. Parts shall be held within the specified temperature range for sufficient time for the necessary transformation and diffusion to take place. The recommended holding times at temperature are listed in Table 2A.

3.2.2.3 Quenching

Material shall be quenched from the austenitizing temperature in the quenchant specified in Tables 1A or 1B, as applicable. Material shall be cooled to or below the quenchant temperature before tempering. Material should be tempered within 2 hours after quench or within 2 hours after reaching room temperature after cold treatment. If hardened parts cannot be tempered within 2 hours of quenching, they can be snap tempered for 1 hour at 400 °F $\pm$ 25 or as appropriate to prevent cracking. Mill products shall be quenched in a manner consistent with commercial practice where Tables 1A and 1B are not applicable. They shall be cooled sufficiently and tempered within a period of time adequate to prevent quench cracking or conditions deleterious to end product mechanical properties and corrosion resistance.