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AEROSPACE MATERIAL SPECIFICATION

AMS 2759

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Revised

HEAT TREATMENT OF STEEL PARTS
General Requirements

1. SCOPE:

1.1 This specification establishes general requirements for the processes listed in 2.1.1 for heat treatment of steel parts (See 8.1.1) by users or their vendors or subcontractors.

1.2 Reference to AMS 2759 on a drawing, fabrication order, purchase order, etc constitutes a requirement to conform to the applicable provisions of the documents listed in 2.1.1 for steel parts of the particular alloy described.

1.3 The conditions (temperatures, soaking times, cooling rates, etc) used by material producers, forge shops, and foundries for qualification of response to heat treatment of their products shall conform to the requirements in the specifications listed in 2.1.1.

1.4 Heat treatment of raw material by raw material producers, forge shops, or foundries should be in accordance with the material procurement specification.

1.5 Processes such as vacuum-furnace heat treating, flame hardening, induction through-hardening, and austempering are recognized heat treating processes, but their requirements are not covered by this specification.

2. APPLICABLE DOCUMENTS: The following publications form a part of this specification to the extent specified herein. The latest issue of Aerospace Material Specifications (AMS) shall apply. The applicable issue of other documents shall be as specified in AMS 2350.

2.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096.

2.1.1 Aerospace Material Specifications:

AMS 2350 - Standards and Test Methods
AMS 2750 - Pyrometry
AMS 2759/1 - Heat Treatment of Carbon and Low-Alloy Steel Parts, Minimum Tensile Strength Up To 220,000 psi (1515 MPa)
AMS 2759/2 - Heat Treatment of Low-Alloy Steel Parts, Minimum Tensile Strength of 220,000 psi (1515 MPa) and Higher
AMS 2759/3 - Heat Treatment of Precipitation Hardening Corrosion Resistant and Maraging Steel Parts
AMS 2759/4 - Heat Treatment of Austenitic Corrosion Resistant Steel Parts

2.2 ASTM Publications: Available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM A370 - Mechanical Testing of Steel Products
ASTM E8 - Tension Testing of Metallic Materials
ASTM E10 - Brinell Hardness of Metallic Materials
ASTM E18 - Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials
ASTM E384 - Microhardness of Materials

2.3 U.S. Government Publications: Available from Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

2.3.3 Military Standards:

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-794 - Parts and Equipment, Procedures for Packaging and Packing of

3. TECHNICAL REQUIREMENTS:

3.1 Equipment and Pyrometry: Thermal processing equipment and related pyrometric equipment shall be controlled in accordance with AMS 2750.

3.1.1 Heating and Refrigeration Equipment: Automatic temperature controllers and data recorders conforming to AMS 2750 are required on each furnace and refrigeration unit. Temperature sensors shall be located in or adjacent to each work zone. Thermocouples shall be protected, when necessary, from contamination. Instrumentation, thermocouples, test equipment, calibration equipment, load thermocouples (See 8.1.2), furnace temperature uniformity, and system accuracy shall conform to AMS 2750.

3.1.2 Quenching Equipment: Quench baths shall permit complete immersion of parts, shall provide for agitation of the quench media or the parts, shall be of sufficient volume to absorb the heat rejected by the most massive part to be quenched, and shall have a temperature indicator with a sensor in the quench media. Quenching baths shall be kept clean.

3.1.3 Auxiliary Equipment: Fixtures, jigs, hangers, trays, racks, etc shall be employed, as needed, for proper handling of parts. Fixtures and fixture materials shall not cause contamination of parts and shall not reduce the heating, cooling, or quenching rates to less than required for correct hardening of parts.

3.1.4 Cleaning Equipment: Equipment shall be provided to clean parts before heat treatment and to remove oil from parts quenched in oil baths and salt residue from parts heated or quenched in salt baths.

3.2 Quenching Media: Except when marquenching (See 8.1.3), the temperature of the quenchant shall be between 75°F and 140°F (25°C and 60°C) at the initiation of the quenching operation, and shall not exceed 200°F (95°C) at any time during the quenching operation, unless otherwise approved by the cognizant (See 8.1.4) engineering organization. In addition, oil for quenching shall be used within the temperature range recommended by the oil manufacturer. Synthetic quenchant may be used when approved by the cognizant engineering organization.

3.3 Procedure:

3.3.1 Cleaning: Parts shall be cleaned before and after heat treatment operations.

3.3.2 Corrosion Protection: Parts shall be protected from corrosion during both processing and storage.

3.3.3 Racking: Parts shall be racked and supported, or otherwise oriented, to ensure access of the heating, cooling, and quenching media to all surfaces of all parts.

3.3.4 Loading: Parts shall not be loaded into a furnace with the temperatuare higher than the set temperature, unless load thermocouples are attached to the part to ensure the part temperature does not exceed the set temperature. The number, location, and method of attachment of load thermocouples shall be approved by the cognizant engineering organization.

3.3.5 Set Temperature: Control instrument(s) shall be set either at the temperature specified by the documents listed in 2.1.1 or at an offset temperature based on the last temperature uniformity survey. The offset temperature shall be within 10 F (5 C) deg of the specified set temperature and shall be posted on the instrument. The offset temperature shall be selected so as to optimize temperature distribution within the furnace so that the highest and lowest temperatures are equidistant from the specified set temperature.

3.3.6 Records: A furnace log, or equivalent documentation such as shop travellers, traceable to temperatuare recorder chart(s) shall be maintained.

3.4 Qualification:

3.4.1 Suppliers: Facilities performing heat treatment in accordance with this specification shall be approved as specified herein by the cognizant quality assurance organization.

3.4.2 Personnel: All personnel at leadman and foreman level responsible for heat treatment in accordance with this specification shall be approved as specified in 4.4.2. There shall be at least one approved person working on each shift.

3.4.3 Equipment: Equipment used for thermal processing in accordance with this specification shall be approved to the requirements of this specification and AMS 2750.

3.5 Test Methods: The following test methods shall be used, when applicable:

3.5.1 Hardness: Shall be determined in accordance with ASTM A370, ASTM E10, ASTM E18, and ASTM E384, as applicable. The approximate conversion of tensile strength requirements to hardness shall be in accordance with ASTM A370. Unless otherwise specified by the cognizant quality assurance organization, hardness tests shall be performed on the thickest section.

3.5.1.1 Rockwell hardness testing machines, when used, shall be checked daily in accordance with ASTM E18, using standard hardness test blocks for the same scale as, and within 10 points of, the hardness of the parts being tested. Brinell machines shall be checked daily, when used, in accordance with ASTM E10, at the loads being used. A record of the daily checks shall be maintained.

3.5.2 Tensile Properties: Testing, when required by the cognizant engineering organization, shall be in accordance with ASTM A370 and ASTM E8.

3.5.3 Salt Bath Neutrality Test: Immerse a piece of SAE 1095 carbon steel shim, nominally 0.003 in. (0.08 mm) thick, into the salt bath at operating austenitizing temperature for 10 min. ± 1. Immediately quench sample in water. Bend the sample until it fractures and examine the fracture surface at approximately 10X magnification. A fracture surface showing no evidence of permanent deformation (yielding or taking a set) is acceptable. If permanent deformation is noted, decarburization has occurred and corrective measures to adjust the salt bath are required.

3.5.3.1 The tests for surface contamination specified in AMS 2759/1 may be used in lieu of, and at the same testing frequency as, the salt bath neutrality test.

3.5.4 Servicing and Calibration of Atmosphere Control Equipment: Instrumentation used to control furnace atmosphere shall be calibrated and serviced according to manufacturer's recommendation.

3.6 Additional Processes: Parts shall not be subject to thermal operations or straightening operations other than those specified, unless permitted by the cognizant engineering organization.

3.7 Strength Ranges: When only a minimum tensile strength is specified and the heat treating processor has the option of selecting the tempering or aging temperature, the maximum tensile strength (converted to hardness) shall be 20,000 psi (140 MPa) above the specified minimum for strength levels up to and including 260,000 psi (1795 MPa) minimum and 25,000 psi (170 MPa) above minimum for strength levels greater than 260,000 psi (1795 MPa) minimum.

3.7.1 When both the minimum tensile strength and the tempering temperature are specified, the maximum strength shall be 30,000 psi (205 MPa) above the specified minimum.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection: Unless otherwise specified by the cognizant quality assurance organization, the heat treating processor shall supply all samples for processor's tests and shall be responsible for the performance of tests and inspections. Results of such tests shall be reported to the cognizant quality assurance organization as required by 4.7. The supplier may use his own facilities or any commercial laboratory acceptable to the cognizant quality assurance organization. The purchaser reserves the right to sample and to perform any confirmatory testing deemed necessary to ensure that processing conforms to the requirements of this specification. The cognizant quality assurance organization may review heat treating records and the results of tests and inspections to verify that heat treatment conformed to all requirements of this specification.

4.1.1 Responsibility for Inspection of Direct Government Orders: Unless otherwise specified in the contract, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, the contractor 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 ensure supplies and services conform to prescribed requirements.

4.2 Classification of Tests:

4.2.1 Acceptance Tests: Tests to determine conformance to requirements for hardness (3.5.1) and tensile strength, when required (3.5.2), are classified as acceptance tests and shall be performed on each lot.

4.2.2 Periodic Tests: Tests to determine conformance to the following requirements are classified as periodic tests and, unless otherwise specified by the cognizant engineering organization, shall be performed at the frequency specified herein on each piece of equipment in service:

4.2.2.1 Daily:

4.2.2.1.1 Salt bath neutrality test (3.5.3) of baths used to heat treat steel to minimum tensile strength of 220,000 psi (1515 MPa) and higher.

4.2.2.1.2 Check of hardness testing machines (3.5.1.1).

4.2.2.2 Weekly:

4.2.2.2.1 Furnace pyrometer system accuracy test (except equipment for stress relieving and baking) as in AMS 2750.

4.2.2.2.2 Salt bath neutraility test (3.5.3) for baths used to heat treat parts to a minimum tensile strength up to 220,000 psi (1515 MPa).

4.2.2.3 Quarterly:

4.2.2.3.1 Calibration of furnace instruments as in AMS 2750.

4.2.2.3.2 Servicing and certification of hardness test machines.

4.2.2.3.3 System accuracy tests and instrument calibration of stress relieving and baking equipment as in AMS 2750. (See 8.1.5 and 8.1.6).

4.2.2.3.4 Temperature uniformity surveys of furnaces as in AMS 2750, except for furnaces used only for annealing, stress relieving, or baking (See 8.1.7). Annually, the survey shall be at the maximum operating temperature.

4.2.2.4 Semi-annually: Temperature uniformity survey of annealing, stress relieving, baking, and controlled subzero transformation equipment as in AMS 2750.

4.2.2.5 Servicing and calibration of atmosphere control measuring equipment at the frequency required in 3.5.4.

4.2.2.6 Calibration of Type B and C instrumentation at the frequency specified in AMS 2750.

4.2.3 Preproduction Tests: Tests to determine conformance to the following requirements are classified as preproduction tests and shall be performed prior to any production heat treating for each piece of equipment to be used:

4.2.3.1 Temperature uniformity survey as in AMS 2750.

4.2.3.2 Pyrometer system accuracy test as in AMS 2750.

4.2.3.3 Instrument calibration as in AMS 2750.

4.2.3.4 Certification of hardness testing machines (3.5.1).

4.2.3.5 Certification of tensile testing machines (3.5.2).

4.2.3.6 Salt bath neutrality test (3.5.3).

4.2.3.7 Calibration of atmosphere control measuring equipment (3.5.4).

4.3 Sampling:

4.3.1 For Hardness Testing:

4.3.1.1 Frequency of hardness testing shall be performed in accordance with the following table. When hardness testing would be destructive or impractical to accomplish, the method for verification of correct heat treatment shall be as specified by the cognizant engineering or quality engineering organization.

Operation	Test Frequency (1)
After final operation (hardening and tempering, aging, etc (See 8.1.8, 8.1.9 and 8.1.10)).	Every part (2), (3)
After intermediate operations, when required. (austenitizing and quenching, annealing, normalizing, solution heat treating, etc (See 8.1.7, 8.1.8, 8.1.11 and 8.1.12)).	One part per lot
After thermal processing subsequent to final hardening operation. (stress relieving, hot or warm straightening, baking prior to plating, etc (See 8.1.5 and 8.1.6)).	One part per lot
After thermal processes subsequent to shot peening, plating, painting, etc (baking after plating, drying, etc).	Not required

(1) Each detail of a weld assembly shall be considered as a separate part.

(2) Statistical sampling is permitted when authorized by the cognizant quality assurance organization or when parts are subjected to 100% testing after thermal processing subsequent to final hardening operation.

(3) When statistical sampling is authorized, random samples shall be selected and tested in accordance with MIL-STD-105 at AQL of 1.5 or less.

4.3.1.2 When heat treating standard components, such as nuts and bolts, for which the frequency of testing is specified, the requirements of the component specifications shall take precedence.

4.3.1.3 The test location shall be the thickest or heaviest section of the part which is practical to test and where the test will not be detrimental to the function of the part.

4.3.2 Lot: Shall be all parts of the same design, fabricated from the same alloy, heat treated to the same property requirements in the same furnace(s) at the same time, and presented for processor's inspection at the same time. In addition, for a continuous furnace it shall be those parts heat treated as a continuous production run during an 8-hr shift. When testing parts after operations (e.g., stress relieving, baking, hot or warm straightening) that occur after the final step of the heat operation (e.g., tempering, aging), a lot, in addition to the above, shall consist of parts stress relieved, baked, hot or warm straightened, etc. using the same equipment at the same time.

4.4 Approval:

4.4.1 Facilities: The approval of a facility shall be in accordance with the following criteria:

4.4.1.1 The heat treating processor shall have a copy of his shop procedure available for the cognizant quality assurance organizations. It shall consist of a full description of all equipment and procedures that will be used to process parts to this specification and the applicable specifications listed in 2.1.1.

4.4.1.2 All equipment shall be tested in accordance with this specification and AMS 2750.

4.4.2 Personnel: Approval of heat treatment personnel by the processing facility's quality assurance organization shall be in accordance with the following three criteria:

4.4.2.1 Completing an apprenticeship program.

4.4.2.2 Passing a written or oral examination covering basic heat treatment theory and practice and the ability to interpret this specification and the applicable documents listed in Section 2.

4.4.2.3 Demonstrating the capability to heat treat parts in their company's facilities and to control the pyrometry and atmosphere control equipment.

4.4.2.4 The apprenticeship program and capability demonstration may be waived if the person has 2 years experience in heat treating. In no case shall the written or oral examination be waived.

4.5 Furnace Log Entries and Recorder Chart Entries:

4.5.1 Each furnace log entry, or equivalent documentation such as a shop traveler, shall be signed by the approved personnel (4.4.2) and shall include the following:

Load number
Part number
Shop order number or customer's purchase order number
Number of parts
Type of material and alloy designation
Equipment identification and furnace number
Thickness of parts (See 8.1.13)
Temperatures and soak times of austenitizing, tempering, solution treating, aging, etc
Type of atmosphere
Dewpoint or other atmosphere control parameter, as applicable
Quench media or cooling method
Required hardness
Actual hardness
Date

4.5.2 Furnace temperature recorder charts and data recorders shall include the following information for each load:

Load number
Shop order number or customer's purchase order number
Number of parts
Time loaded (with AM, PM denoted)
Time soaking commenced
Time soaking was completed
Verification of alignment of recorder chart with the scale
Responsible personnel's identification
Furnace number
Date

4.6 Records: Unless otherwise specified, furnace logs, recorder charts, all other shop records, and test and inspection records shall be kept available to the cognizant quality assurance organization for a period of 5 years after heat treatment. The records shall contain all data necessary to verify conformance to the requirements of this specification.