



# AEROSPACE MATERIAL SPECIFICATION

AMS2759™

REV. G

Issued	1984-10
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Revised	2019-04

Superseding AMS2759F

## Heat Treatment of Steel Parts General Requirements

### RATIONALE

AMS2759G results from making corrections to types of parts (3.2.2.2.3), test specimen hardenability (3.10.3.1.5.1, 3.10.3.1.5.2, and 3.10.3.1.5.3), and surface contamination (3.12.1); and deletion of quench media control (3.10.3.3.1.4) and the fourth bullet point in 3.10.3.3.2. Start of soaking (3.8.7) was moved from the notes.

### NOTICE

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

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

- AMS2759G
- Quantity of parts
- Part number or part identity
- Material alloy designation of parts
- Heat treating operations required
- Final heat treatment condition required
- Processing variables, if not defined or different from the applicable slash specification. Examples of such requirements include but not limited to: processing temperatures, times, and other parameters, class of atmosphere required, part type, allowance for straightening, post straightening thermal operations requirements, pre-cleaning and post-cleaning requirements, post heat treatment corrosion protection requirements.
- Additional ordering information as required by the appropriate slash specification. Examples of such requirements include but not limited to: present condition of parts, pre heat treatment surface protection (e.g., Cu plating), any restriction from the applicable slash specification (e.g., Vacuum only or Salt bath only).

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## 1. SCOPE

- 1.1 This specification establishes general requirements for the processes listed in 3.8.1 for heat treatment of steel parts (see 8.2.1) by users or their vendors or subcontractors.
- 1.2 Reference to AMS2759 on a drawing, fabrication order, purchase order, etc., constitutes a requirement to conform to the applicable provisions of the documents listed in 3.8.1 for the heat treatment of steel parts of the particular alloy described. Parts made from steels other than those specified in the detail specifications may be heat treated in accordance with the applicable requirements using processing temperatures, times, and other parameters recommended by the material producer unless otherwise specified by purchaser.
- 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 of the specifications listed in 3.8.1.
- 1.4 Heat treatment of raw material by raw material producers, forge shops, or foundries shall be in accordance with the material procurement specification.
- 1.5 Processes such as flame hardening, induction through-hardening, laser hardening, austempering, martempering, and hot oil quenching are recognized heat treating processes, but their requirements may not be completely covered by this specification.
- 1.6 The provisions of this specification revision shall become effective 90 days after publication.
- 1.7 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 that 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.

## 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 processor 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 and Canada), [www.sae.org](http://www.sae.org).

AMS2750	Pyrometry
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 of Austenitic Corrosion-Resistant Steel Parts
AMS2759/5	Heat Treatment Martensitic Corrosion-Resistant Steel Parts
AMS2759/6	Gas Nitriding of Low-Alloy Steel Parts

AMS2759/7	Carburizing and Heat Treatment of Carburizing Grade Steel Parts
AMS2759/8	Ion Nitriding
AMS2759/9	Hydrogen Embrittlement Relief (Baking) of Steel Parts
AMS2759/10	Automated Gaseous Nitriding Controlled by Nitriding Potential
AMS2759/11	Stress Relief of Steel Parts
AMS2759/12	Automated Gaseous Nitrocarburizing, Controlled by Potentials
AMS2759/13	Gaseous Nitrocarburizing
AMS2769	Heat Treatment of Parts in a Vacuum
AMS-H-6875	Heat Treatment of Steel Raw Materials
ARP1820	Chord Method of Evaluating Surface Microstructural Characteristics
ARP1917	Clarification of Terms Used in Aerospace Metals Specifications
ARP1962	Training and Approval of Heat-Treating Personnel
AS1260	Equivalent Sections of Certain Shapes to Round Bars

## 2.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9598, [www.astm.org](http://www.astm.org).

ASTM A255	Determining Hardenability of Steel
ASTM A304	Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements
ASTM A370	Mechanical Testing of Steel Products
ASTM D6200	Determination of Cooling Characteristics of Quench Oils by Cooling Curve Analysis
ASTM D6482	Determination of Cooling Characteristics of Aqueous Polymer Quenchants by Cooling Curve Analysis with Agitation (Tensi Method)
ASTM D6549	Determination of Cooling Characteristics of Quenchants by Cooling Curve Analysis with Agitation (Drayton Unit)
ASTM D6710	Evaluation of Hydrocarbon-Based Quench Oil
ASTM E8/E8M	Tension Testing of Metallic Materials
ASTM E10	Brinell Hardness of Metallic Materials
ASTM E18	Rockwell Hardness of Metallic Materials
ASTM E110	Rockwell and Brinell Hardness of Metallic Materials by Portable Hardness Testers
ASTM E384	Microindentation Hardness of Materials

### 2.3 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil/>.

MIL-STD-867 Temper Etch Inspection

### 2.4 ANSI Accredited Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ANSI/ASQC Z1.4 Sampling Procedures and Tables for Inspection by Attributes

ISO 9950 Industrial Quenching Oils - Determination of Cooling Characteristics - Nickel-Alloy Probe Test Method

## 3. TECHNICAL REQUIREMENTS

### 3.1 Pyrometry

Thermal processing equipment including refrigeration equipment (see 3.4.1) shall meet the requirements of AMS2750. Furnaces shall have a minimum of Type D instrumentation.

### 3.2 Furnace Equipment

3.2.1 Furnace Classes are as defined in AMS2750 and are based on the minimum requirements for temperature uniformity. Unless otherwise specified in the applicable slash specification (see 3.8.1), furnace classes shall be as follows:

3.2.1.1 Furnace classes for annealing, subcritical annealing, normalizing, hardening austenitizing or solution treating, and stress relieving shall be Class 5 or better.

3.2.1.2 Furnace classes for tempering or aging/precipitation hardening shall be Class 3 or better.

3.2.1.3 Furnace classes for certain specific materials and processes are contained in the individual specification (see 3.8.1).

### 3.2.2 Heating Environment

#### 3.2.2.1 Atmospheres

##### 3.2.2.1.1 Classes of Atmospheres

3.2.2.1.1.1 Class A: Argon, hydrogen, helium, nitrogen, nitrogen-hydrogen blends, vacuum, or neutral salt. Nitrogen from dissociated ammonia is not permitted.

3.2.2.1.1.2 Class B: Endothermic, exothermic, or carbon-containing nitrogen-base.

3.2.2.1.1.3 Class C: Air or products of combustion.

##### 3.2.2.1.2 Atmosphere Control

Atmosphere furnaces shall be controlled to ensure that surfaces of heat treated parts are within the limits specified in the individual slash specification in Table 1.

### 3.2.2.1.2.1 Class A Atmospheres, Inert Gas Bulk Delivery

The composition and dew point of the process gas shall be in accordance with the applicable requirements in 2.4 and as required by the individual slash specification and traceable to a certificate of conformance. The dew point of the gas shall be -60 °F (-51 °C) or lower as the gas enters the furnace and shall be verified at least quarterly and also when the piping transmitting the gas is disturbed. In lieu of sampling the dew point at each furnace, the gas may be sampled at the end of each leg of supply piping, at the furthest point from the supply.

### 3.2.2.1.2.2 Servicing and Calibration of Atmosphere Control Equipment

Instrumentation used to control furnace atmosphere shall be calibrated and serviced according to manufacturer's recommendation or by a suitable comparison method assuring the required accuracy is met, and in accordance with heat treater's documented procedures.

### 3.2.2.2 Types of Parts

Parts shall be controlled by type, as follows, and heat treated in the class of atmosphere permitted for that type.

#### 3.2.2.2.1 Type 1

Parts with 0.020 inch (0.51 mm) or more to be removed from all surfaces after heat treatment and parts with hot finished (as-forged, as-cast, or hot mill) surfaces at time of heat treatment with all surfaces to be removed after heat treatment.

#### 3.2.2.2.2 Type 2

Parts with finished surfaces, surfaces with less than 0.020 inch (0.51 mm) to be removed after heat treatment (including hot finished surfaces that will remain on the part), or combinations of these.

3.2.2.2.3 If part type cannot be determined, the part shall be processed as Type 2. For parts previously determined to be Type 3 or Type 4, the parts shall be processed as Type 2.

3.2.2.3 Parts with protective coating on all surfaces shall be processed in an atmosphere that will not destroy the coating during heat treatment.

### 3.3 Quenching Equipment

The Quench System equipment and quench media (see 3.10.3.3) shall be sufficient to achieve the properties required by the heat treat process.

3.3.1 When quenching in vacuum furnaces using gas quenching, the quenching media and conditions shall be in accordance with AMS2769.

### 3.4 Auxiliary Equipment

Fixtures and fixture materials shall not cause contamination of parts.

#### 3.4.1 Sub-Zero Cooling or Deep Freeze

When required to complete transformation and provide desired microstructure, parts shall be cooled to a temperature within the range specified in the applicable slash specification, held at the selected temperature for a time commensurate with section thickness, and warmed in air to room temperature.

### 3.5 Cleaning Equipment

Equipment shall be provided to clean parts before heat treatment, to remove oil from parts quenched in oil baths, and salt residue from parts heated or quenched in salt baths. When using polymer quenchants, a rinsing system shall be in place to remove quenchant from the parts.

### 3.6 Vacuum Furnace Equipment

Vacuum furnaces shall meet the requirements of AMS2769.

### 3.7 Quenching Media

Quenching media shall be as specified in slash sheets.

3.7.1 Oil quenchants shall be in the range of 60 to 160 °F (16 to 71 °C) at the initiation of the quench operation. Oils shall not be used at temperatures exceeding the manufacturer's recommended maximum temperature.

3.7.2 Polymer quenchants shall be in the range of 60 to 110 °F (16 to 43 °C) at the initiation of the quench operation or at a temperature specified by the manufacturer.

#### 3.7.3 Quenching from Salt Bath Furnaces

Water shall be monitored to ensure salt content does not exceed 2% by weight. Polymers shall be monitored to ensure salt content does not exceed 6% by weight.

### 3.8 Procedures

#### 3.8.1 Heat Treatment

Shall be in accordance with the applicable slash specification for the material and process listed in Table 1. In case of conflict between AMS2759 and the slash specification, the slash specification shall take precedence.

**Table 1 - Heat treatment procedures**

Type of Steel or Process	Procedure
Carbon and Low-Alloy Below 220 ksi UTS	AMS2759/1
Low-Alloy 220 ksi UTS and Higher	AMS2759/2
PH and Maraging	AMS2759/3
Austenitic	AMS2759/4
Martensitic	AMS2759/5
Gas Nitriding	AMS2759/6
Gas and Vacuum Carburizing	AMS2759/7
Ion Nitriding	AMS2759/8
Hydrogen Embrittlement Relief (Baking) of Steel Parts	AMS2759/9
Automated Gaseous Nitriding Controlled by Nitriding Potential	AMS2759/10
Stress Relief of Steel Parts	AMS2759/11
Gaseous Nitrocarburizing, Automatically Controlled by Potentials	AMS2759/12
Gaseous Nitrocarburizing	AMS2759/13
Heat Treatment of Parts in a Vacuum	AMS2769

#### 3.8.2 Cleaning

Parts shall be in a clean condition before heat treatment. All salt residue shall be removed from parts processed in salt baths or quenched in brine.

3.8.2.1 The purchaser shall supply clean parts to the processor or specify the cleaning method prior to heat treatment, to the processor. Parts shall be visually inspected to verify freedom from grease, dirt, oil, corrosion and corrosion preventive coatings. Use of magnification as a referee for part inspection is permitted.

3.8.2.2 Following heat treatment operations, parts shall be cleaned when specified. Post heat treat cleaning is not required unless specified.

### 3.8.3 Racking

Parts shall be racked and supported, or otherwise oriented, to ensure free circulation of the heating, cooling, and quenching media to all surfaces of all parts and to minimize warpage.

### 3.8.4 Purging

Whenever active atmosphere types (e.g., neutral, carburizing, nitriding) are changed and when the prior atmosphere can have a deleterious effect on the subsequent parts being processed, prior to heating of parts, remnants of the previous atmosphere shall be removed from the furnace or retort and gas supply lines. For atmosphere furnaces, this shall be accomplished by purging with at least five volume changes of the purge gas or for a sufficient time, flow rate and temperature as verified by testing. For vacuum furnaces or atmosphere furnaces equipped with a vacuum pump, this shall be accomplished by pumping to the furnace's typical lowest vacuum level. This requirement does not apply to Type 1 parts or if the heat treater has documented confirmation that material removal after heat treatment will ensure that all surfaces of finished parts will be free from contamination.

### 3.8.5 Loading

Parts shall not be loaded into a furnace with the temperature higher than the set temperature, unless load sensors are attached to the part to ensure the part temperature does not exceed the set temperature.

### 3.8.6 Set Temperature

Control instrument(s) shall be set at the temperature specified by the slash specifications listed in 3.8.1.

### 3.8.7 Start of Soaking

3.8.7.1 When only furnace control sensors are used, soaking time starts when the temperature indicated by the furnace control instrument recovers to within 5 °F (3 °C) of the set heat treating temperature.

3.8.7.2 When furnace control sensors and recording thermocouples are used, soaking time starts when the temperature indicated by all recorded sensors reaches the minimum of the required temperature tolerance applicable to the set heat treating temperature.

3.8.7.3 When load thermocouples are used, soaking time starts when the part temperature reaches the minimum of the required temperature tolerance for the set heat treating temperature.

### 3.8.8 Salt Bath Additives

Shall be limited to the salts in the bath and to additives recommended by the salt manufacturer.

### 3.8.9 Records

A furnace log, or equivalent documentation such as shop travelers, traceable to temperature recorder chart(s), shall be maintained.

## 3.9 Qualification

### 3.9.1 Processors

Facilities performing heat treatment in accordance with this specification shall be approved as required in 4.4.1.

### 3.9.2 Personnel

All personnel performing heat treating, testing, inspection, and associated operations shall be trained and approved in accordance with documented Quality Assurance procedures. ARP1962 is an acceptable recommended practice.

### 3.10 Test Methods

#### 3.10.1 Hardness

Shall be determined in accordance with ASTM A370, ASTM E10, ASTM E18, and ASTM E384, as applicable. Portable hardness testing, in accordance with ASTM E110, may be used when the size or configuration of parts is such that bench testing is impractical. To verify conformance to the tensile requirements, the approximate conversion of hardness to tensile strength in ASTM A370 shall be used. Hardness tests shall be performed on the thickest section, unless otherwise specified.

3.10.1.1 Hardness of parts shall be as specified by the applicable slash specification or the purchase order.

#### 3.10.2 Tensile Properties

Shall be determined in accordance with ASTM E8/E8M at a strain rate of 0.005 in/in/min.

3.10.2.1 When tensile testing is required to accept the parts, the purchaser shall provide all test materials.

#### 3.10.3 Quench System Monitoring

The quench system includes the quench volume, type of fluid, recirculation velocity and uniformity, and heat exchange capacity. The consistency of the quench system shall be monitored quarterly, by processing test parts, as outlined below, which are capable of detecting changes in the cooling characteristics of the system. Testing of water quench systems is not required. Quench system monitoring test procedures other than those described in 3.10.3.1 shall be approved by the cognizant engineering authority. When destructive mechanical property testing is required for part acceptance, quench system monitoring is not required.

##### 3.10.3.1 Test Specimen Requirements

###### 3.10.3.1.1 Test Specimen Alloy/Configuration

3.10.3.1.1.1 Round specimens of carbon or low alloy steel, of appropriate hardenability and dimensions shall be used. Selection of the specimen dimensions/hardenability combination shall be aimed at achieving full hardening (e.g., 95% martensite) at the center of the specimen. The specific combination of alloy/dimensions chosen shall be such that the specimen would not be capable of achieving full hardening at 1.25 times the diameter chosen for the test specimen. The length of the test specimen shall be at least three times the diameter.

3.10.3.1.1.2 The test specimens used for the initial and subsequent evaluation of a particular quenchant shall be from the same alloy and preferably the same chemistry heat of material to eliminate material chemistry and hardenability differences from the alloy selection. Hardenability results shall not be lower than that represented by requirements in 3.10.3.1.5.

3.10.3.1.2 Test specimen alloy/dimensions shall be one of the following:

- a. 4130 round bar, minimum 1.50 inches (3.81 cm) long, 0.50 inch (1.27 cm) nominal diameter.
- b. 4140 round bar, minimum 4.50 inches (11.43 cm) long, 1.50 inches (381 cm) nominal diameter.
- c. 4330V round bar, minimum 7.50 inches (19.05 cm) long, 2.5 inches (6.35 cm) nominal diameter.
- d. Other material and dimensional requirements established in pre-production testing or as specified by the cognizant engineering organization. See 8.5 for shape equivalent guidelines.

###### 3.10.3.1.3 Test Specimen Processing

Quarterly quench system monitoring tests shall be run with a typical or simulated production load. Heat treat loads shall be processed in accordance with the appropriate AMS2759 slash specification requirements.

### 3.10.3.1.4 Specimen Testing Requirements

After quenching the test specimen, a 0.5 inch thick specimen shall be cut from the center of the test specimen length and prepared for hardness testing in the untempered condition. Specimen shall be prepared to ensure it is free from overheating. The minimum hardness at the center of the diameter shall meet the hardness requirements of the approved procedure in 3.10.3.

### 3.10.3.1.5 Test Specimen Hardenability

#### 3.10.3.1.5.1 Round Bar Specimen 4130

After quenching, the center of the diameter shall not be less than the hardness on the end-quench hardenability curve corresponding to the diameter of the specimen when tested in accordance with ASTM E18. The end-quench hardenability curve shall be the actual hardenability curve determined in accordance with ASTM A255 on the material used for the test specimen.

#### 3.10.3.1.5.2 Round Bar Specimen 4140

The hardness in the center of the diameter shall not be less than HRC 44 and the 3/4 radius shall not be less than HRC 50 when tested in accordance with ASTM E18.

#### 3.10.3.1.5.3 Round Bar Specimen 4330V

The hardness in the center of the diameter shall not be less than the hardness on the end-quench hardenability curve corresponding to the diameter of the specimen when tested in accordance with ASTM E18. The end-quench hardenability curve shall be the actual hardenability curve determined in accordance with ASTM A255 on the material used for the test specimen.

3.10.3.1.5.4 If other combinations are established, the accept/reject criteria shall be as specified in the ordering information.

3.10.3.1.5.5 It is the responsibility of the heat treater to provide the material and hardenability data specified above.

3.10.3.2 Any failures shall be documented by the heat treater's corrective action system.

3.10.3.2.1 As a minimum, if the test specified in 3.10.3 fails, the quench medium shall be analyzed as specified in 3.10.3.3.

### 3.10.3.3 Quench Media Control

3.10.3.3.1 Each new shipment of quenchant from a vendor shall meet the requirements for the particular quenchant listed in 3.10.3.3.1.1 through 3.10.3.3.1.3 as applicable. The vendor shall furnish a certificate of conformance stating that the quenchant meets the requirements including, in addition to the vendor designation, the cooling curve, the cooling rate curve, the maximum cooling rate, and:

3.10.3.3.1.1 For mineral oil based quenchants, the certificate shall also include the viscosity, flash point, temperature at the maximum cooling rate.

3.10.3.3.1.2 For vegetable or ester-based oil quenchants, the certificate shall also include the viscosity, flash point, temperature at the maximum cooling rate.

3.10.3.3.1.3 For polymer quenchants, the certificate shall also include the undiluted pH and viscosity. The pH, viscosity, maximum cooling rate and the temperature at the maximum cooling rate shall be provided at 20% concentration by weight.

3.10.3.3.2 Cooling curve tests shall be performed semi-annually, or when required by corrective action (3.10.3.2), in accordance with ASTM D6200, ISO 9950 or JIS K 2242, ASTM D6482, or ASTM D6549, as applicable to the specific quench medium. If no alternative limits have been established by pre-production tests or specified by the cognizant engineering authority, exceeding the following limits compared to the initial shipment of quenchant shall be cause for corrective action:

- For mineral oils:

Temperature of the Maximum Cooling Rate: ( $\pm 68$  °F) (37.8 °C)

Maximum Cooling Rate: ( $\pm 25$  °F/s) (13.9 °C/s)

- For vegetable or ester-based oils:

Maximum Cooling Rate: ( $\pm 25$  °F/s) (13.9 °C/s)

Temperature of the Maximum Cooling Rate: ( $\pm 68$  °F) (37.8 °C)

- For polymer quenchants:

Maximum Cooling Rate:  $\pm 15\%$

Temperature of the Maximum Cooling Rate:  $\pm 15\%$

#### 3.10.4 Surface Contamination Test Methods

3.10.4.1 Micro-Hardness measurement testing for the determination of partial decarburization, shall be performed using the microindentation hardness method in accordance with ASTM E384. If specified for greater accuracy of near surface hardness evaluation, the chord method of ARP1820 shall be used. Test specimens shall, as a minimum, be of the same alloy as the parts. Evaluation of the test specimens shall be in the as-quenched condition except that secondary hardening steels, such as H-11, shall be tempered.

3.10.4.2 Direct hardness measurement testing for the determination of partial decarburization shall be in accordance with ASTM E18, with the depth as defined in 8.3. Use of bulk surface hardness testing using a comparison of one or more superficial hardness scales (A, N) with Rockwell C measurements shall be used.

3.10.4.3 Visual determination for the presence of complete decarburization, carburization, and nitriding shall be determined by etching with the appropriate etchant and examining at a magnification of 200X minimum, or as specified in the individual slash specification requirement. Examples are shown in ASTM E1077.

3.10.4.4 Depth of intergranular attack shall be determined metallographically on an unetched specimen at a minimum magnification of 200X, or as specified in the individual slash specification requirement.

#### 3.10.5 Rejection Criteria

3.10.5.1 Rejection criterion for depth of partial decarburization using the microindentation hardness method shall be the depth at which the hardness reading is 25 points Knoop, or equivalent, lower than the average core hardness.

3.10.5.2 Rejection criteria for nitriding and carburizing shall be the depth at which the hardness reading is 25 Knoop (or equivalent) higher than the average core hardness.

3.10.5.3 When using the direct hardness method (3.10.4.2), the rejection criteria shall be the depth where the superficial hardness test differs by more than 1.5 HRC from the direct surface hardness reading in HRC.

#### 3.11 Additional Processes

Parts shall not be subjected to thermal operations other than those specified in the ordering document.

### 3.12 Properties

#### 3.12.1 Surface Contamination

Shall be controlled when heating parts above 1250 °F (677 °C) and evaluated as follows in accordance with at least one of the methods stated in 3.10.4:

3.12.1.1 When less than 0.020 inch (0.051 mm) of metal is to be removed from any surface, the heat treat medium (protective atmosphere or salt baths), shall be controlled to prevent carburization or nitriding and to prevent complete decarburization. Testing shall be in accordance with 3.10.5. Partial decarburization, carburization or nitriding shall not exceed 0.003 inch (0.075 mm). Intergranular attack and complete decarburization shall not exceed 0.0007 inch (0.018 mm).

3.12.1.2 Unless specified that at least 0.020 inch (0.51 mm) will be removed from all surfaces of parts, the heat treating processor shall heat treat the parts as if less than 0.020 inch (0.51 mm) will be removed.

3.12.1.3 Parts that will be machined after heat treatment, but that will have less than 0.020 inch (0.51 mm) of metal removed from any machined surface may be reclassified as Type 1, by the purchaser and need not meet the requirements of 3.12.1.1 as heat treated.

3.12.1.4 Each furnace load shall contain test specimens of the same alloy family as the parts. The surface contamination requirements also apply to the cumulative effects of operations such as normalizing followed by austenitizing or austenitizing followed by re-austenitizing. For reheat treatments, the original specimen or a portion thereof shall accompany the parts and be tested after the reheat treatment.

3.12.1.5 Parts that will have all contamination removed shall not require testing.

3.12.1.6 For nitriding and carburizing processes (for example, when processing to AMS2759/6, etc.), testing for surface contamination is not required, but the parts must be certified to be free from surface contamination by the Purchaser.

#### 3.12.2 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 20.0 ksi (138 MPa) above the specified minimum for strength levels up to and including 260 ksi (1793 MPa) minimum and 25.0 ksi (172 MPa) above minimum for strength levels over 260 ksi (1793 MPa) minimum.

3.12.2.1 When both the minimum tensile strength and the tempering temperature are specified, the maximum strength shall be 30.0 ksi (207 MPa) above the specified minimum.

## 4. QUALITY ASSURANCE PROVISIONS

### 4.1 Responsibility for Inspection

The processor shall be responsible for the performance of all required tests and inspections. The processor may use his own facilities or any commercial laboratory. Purchaser and the cognizant quality assurance organization reserve the right to sample and to perform any confirmatory testing deemed necessary to ensure that processing conforms to specified requirements. The purchaser and the cognizant quality assurance organization may review heat treating records and the results of tests and inspections to verify that heat treatment conforms to specified requirements.

### 4.2 Classification of Tests

#### 4.2.1 Acceptance Tests

Acceptance tests shall be as specified in the detailed slash specifications (see Table 1).

#### 4.2.2 Periodic Tests

Periodic tests shall be as specified in the detailed slash specifications (see Table 1). The following requirements are equipment periodic tests and shall be performed at the frequency specified herein on each piece of equipment in service.

##### 4.2.2.1 Weekly

4.2.2.1.1 Salt content monitoring of water and polymer quenchants when quenching from salt bath furnaces (3.7.3).

##### 4.2.2.2 Quarterly

4.2.2.2.1 Quench System Monitoring (3.10.3)

##### 4.2.2.3 Semi-Annually

4.2.2.3.1 Quench media Cooling Rate Determination (3.10.3.3.2)

#### 4.2.3 Preproduction Tests

All periodic tests are preproduction tests and shall be performed prior to the first production run.

#### 4.3 Sampling and Testing

##### 4.3.1 For Hardness Testing

4.3.1.1 Frequency of hardness testing shall be in accordance with Table 2.

4.3.1.2 When hardness testing, including portable, would be destructive or impractical to accomplish, the method for verification of correct heat treatment shall be as specified by the cognizant engineering organization.

4.3.1.3 Other heat treat verification procedures are acceptable if approved by the cognizant engineering organization.

**Table 2 - Hardness testing**

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

**NOTES:**

- Each detail of a weld assembly or braze assembly shall be considered as a separate part.
- 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.
- When statistical sampling is authorized, random samples shall be selected and tested in accordance with ANSI/ASQC Z1.4 at AQL of 1.5 or less.

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

4.3.1.5 Unless otherwise specified, the test location shall be the thickest or heaviest section of the part.

#### 4.4 Approval

##### 4.4.1 Heat Treat Processor's Facilities

The approval of a facility shall be in accordance the requirements of the cognizant quality assurance organization and the following criteria:

4.4.1.1 The procedures of the heat treating processor shall be available for review. 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 slash specifications listed in 3.8.1.

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

##### 4.4.2 Personnel

Training and approval of personnel shall be in accordance with 3.9.2.

#### 4.5 Records

A record (written or electronic storage media), traceable to temperature recording information (chart(s) or electronic storage media) and to shop paperwork or other documentation, shall be kept for each furnace and load. The log data shall be recorded in accordance with the heat treat processor's documented procedures.

#### 4.6 Record Retention

All production, test, and inspection records shall be kept and made available upon request of the purchaser to the cognizant quality assurance organization for at least 5 years after heat treatment, or for the duration specified by the purchaser. The records shall contain all data necessary to verify conformance to specified requirements.

#### 4.7 Report/Certification

The heat-treating processor shall furnish, with each shipment of parts, a certified quality assurance report, traceable to the heat treat control number(s), stating that the parts were processed in accordance with the requirements of the applicable AMS2759 detailed specification listed in Table 1 or other applicable specification. The report shall include: purchase order number, part number or product identification, alloy, temper/strength designation, and quantity of parts in the shipment. When applicable, by contract or purchase order, the report shall also include: atmosphere type, quenchant (including polymer concentration range), hot straightening temperature and method of straightening (e.g., press, fixtures), identification of furnaces used, actual processing times and temperatures used, and a statement of their conformance/nonconformance to requirements. This data shall be reported in accordance with the heat treat processor's documented procedures.

##### 4.7.1 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-hour 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.

#### 4.8 Corrosion Protection

Parts susceptible to corrosion (primarily carbon and low alloy steels, some martensitic stainless steels) shall be protected from corrosion during processing and storage.

### 5. PREPARATION FOR DELIVERY

#### 5.1 Identification

Traceability of parts or product provided to the heat treat processor shall be maintained from receipt, through to the completion of processing or delivery.

#### 5.2 Packaging

5.2.1 When specified by the purchaser, parts shall be protected with corrosion preventive compounds when shipped.

5.2.2 Parts shall be packaged to ensure protection from damage during shipment and storage.

5.2.3 Packages of parts shall be prepared for shipment in accordance with commercial practice and in compliance with applicable rules and regulations pertaining to the handling, packaging, and transportation of the parts to ensure carrier acceptance and safe delivery.

### 6. ACKNOWLEDGMENT

A vendor shall include this specification number and its revision letter in all quotations and when acknowledging purchase orders.

### 7. REJECTIONS

Parts not heat treated in accordance with this specification, or with modifications authorized by the cognizant engineering organization, will be subject to rejection and shall be submitted for disposition in accordance with purchaser's procedures for nonconformance.

### 8. NOTES

#### 8.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

8.2 Terms used in AMS are clarified in ARP1917 and as follows:

#### 8.2.1 Parts

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

#### 8.2.2 Cognizant

The term applied to the engineering organization responsible for the design of the parts, or its allied quality assurance organization, or a designee of these organizations.

### 8.2.3 Baking

Heating parts (that are in the final heat treated condition and have been subjected to an embrittling operation, such as pickling, plating, etc.) in order to remove hydrogen from the parts. This operation is normally performed at 375 °F (191 °C) but is always at a temperature lower than the tempering, aging, etc., temperature.

### 8.2.4 Solution Heat Treating (Solution Annealing)

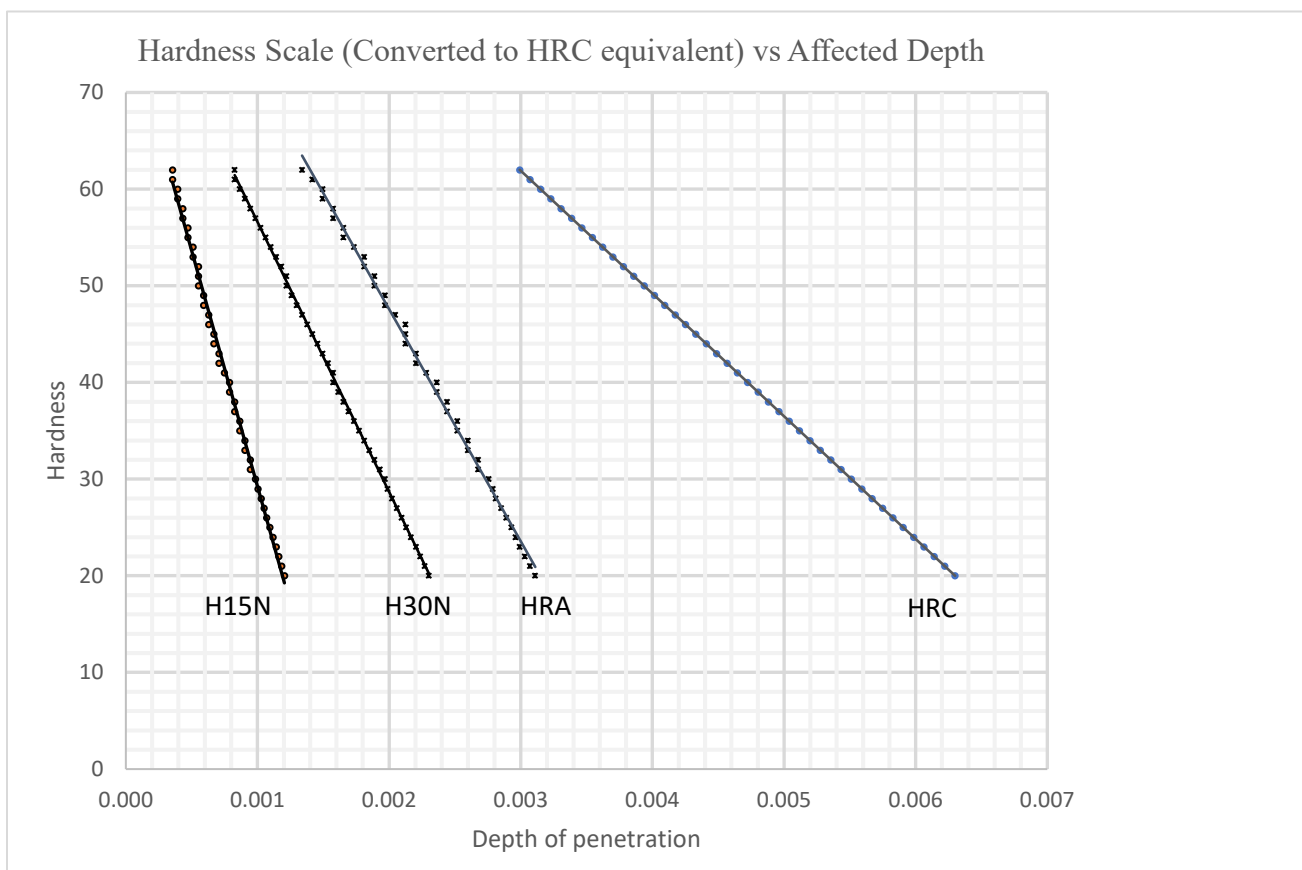
Heating to a sufficiently high temperature, followed by cooling to hold one or more elements in solution for subsequent precipitation hardening.

### 8.2.5 Thickness

The minimum dimension of the heaviest section of the part.

### 8.3 Superficial Hardness as an indicator of decarburization.

The depth of penetration of the indenter used in the Rockwell hardness test is a function of the hardness of the material deformed by the indenter. The correlation between hardness scales and depth of penetration, using the scale conversions in ASTM E18, can be plotted and is shown in Figure 1. Using these relationships, the presence of decarburization and the depth can be determined by using two or more measurement scales on the heat treated surface.



**Figure 1**

For example, if a direct hardness measurement using the Rockwell C scale shows a hardness of HRC 60, and there is zero decarburization, a superficial hardness test using the 15 Nm 30 N or A scales would show a hardness (when converted to the C scale) of the same value, HRC 60.

On the other hand, if there was, for example, 0.001 inch decarb, a 15 N or 30 N measurement would measure lower than HRC 60, depending upon the degree of decarb.

As a result, the comparative scales can give an indication of the degree of partial decarburization that can be used as a go/no-go criterion.

8.4 Although the results of both tests and production experience have shown that polymer quenchants can be successfully substituted for oil quenchants for even highly hardenable steels, the wide difference of cooling characteristics achieved with different types of polymers and concentration levels requires that the validation procedure be targeted specifically toward the intended polymer/concentration. When substituting a polymer/concentration for an existing oil quenchant, the quenchant validation procedure must ensure that the polymer and concentration being substituted achieves cooling characteristics that are similar to the existing oil quenchant and that the properties being produced are equivalent to those for oil quenched parts.

8.5 Equivalent Sections of Certain Shapes to Round Bars

AS1260 indicates the approximate equivalence of various shapes to equivalent round sections.

8.6 Dimensions and properties in inch/pound units and the Fahrenheit temperatures are primary; dimensions and properties in SI units and the Celsius temperatures are shown as approximate equivalents of the primary units and are presented only for information.

8.7 Similar Specifications

AMS-H-6875 (for raw material).

PREPARED BY AMS COMMITTEE "E" AND AMEC