



AEROSPACE MATERIAL SPECIFICATION

AMS2745™**REV. B**

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Superseding AMS2745A

Induction Hardening of Steel Parts

RATIONALE

AMS2745B is the result of a Five-Year Review and update of the specification. The document includes, updates to align with other process specification, including specific ordering information requirements (see NOTICE), revises reference to drawings throughout to "specified results," updates classes to align with AS9100/AS9103 (see 1.2), adds hardening (see 3.3.1), adds tempering specifications and procedure (see 3.3.2), replaces Knoop and Brinell with Rockwell C or microhardness test methods (see 3.4.6), revises lot definition (see 4.3), and adds cognizant engineering approval (see 4.3, 4.3.5.1, 4.6.2, 4.6.3, and Section 7).

NOTICE

ORDERING INFORMATION: The purchaser shall supply the following information to the heat-treating processor.

- AMS2745B
- Class of the part (see 1.2)
- Part number and full description of hardening zones or patterns required, and if simulated parts are to be used for destructive testing (see 3.2 and 3.4.1)
- The engineering drawing and other specified requirements (see 3.2)
- Material type and condition (see 3.2)
- Whether post induction hardening machining is required, and if so, minimum and/or maximum amount of stock to be removed (see 3.2)
- Locations and required values of hardness and microhardness (see 4.2)
- Cognizant Engineering Organization (see 4.4)

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1. SCOPE

This specification defines the requirements for locally hardening steel parts by the induction hardening method.

1.1 Application

This procedure has been used typically to harden local areas of parts without heating the entire part to hardening temperatures or to harden a local area of a part to a higher hardness than surrounding areas for increased wear or strength, often at the expense of other characteristics such as toughness, but usage is not limited to such applications.

1.2 Classification

Induction hardened parts are classified as follows:

Class 1 - Critical item (refer to AS9100 and AS9103)

Class 2 - Key characteristic (refer to AS9100 and AS9103), such as structural

Class 3 - Not otherwise defined as a critical item or a key characteristic

1.2.1 When a class is not specified, Class 2 shall be supplied.

2. REFERENCES

2.1 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.

2.2 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.

AMS2649	Etch Inspection of High Strength Steel Parts
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
AMS2759/5	Heat Treatment, Martensitic Corrosion-Resistant Steel Parts
ARP4715	Induction Hardening of Steel Components
AS7766	Terms Used in Aerospace Metals Specifications
AS9100	Quality Management Systems - Requirements for Aviation, Space, and Defense Organizations
AS9103	Aerospace Series - Quality Management Systems - Variation Management of Key Characteristics

2.3 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 E18 Rockwell Hardness of Metallic Materials

ASTM E112 Determining Average Grain Size

ASTM E384 Microindentation Hardness of Materials

2.4 Definitions

Terms are defined in AS7766 and as follows:

2.4.1 STEEL

The term "steel," as used herein, is generic and applies to any steel that is amenable to induction hardening. It includes carbon and low alloy steels, tool steels, and some grades of cast irons and martensitically hardenable corrosion-resistant steels.

3. TECHNICAL REQUIREMENTS

3.1 Equipment

3.1.1 Induction heating equipment shall consist of the following:

- A suitable power supply, the relationship between frequency and depth of hardening is given in ARP4715.
- Controls adequate to reproduce the power, ramp rates (if used), and power on-time from one part to the next.
- An inductor coil, specifically identified with the part to be hardened.

3.1.1.1 Quench/cooling capability, as applicable, to produce the desired metallurgical state.

3.2 Documentation

Process and control procedures shall have been demonstrated to produce the specified results. At a minimum these procedures shall contain the following:

- Part number or other full description of the part including description of any simulated part used for destructive testing
- Description or type of base metal, if not specified
- Condition of base metal prior to induction hardening
- Whether post induction hardening machining is required, and, if so, minimum and/or maximum amount of stock to be removed
- Coil or inductor identification or part number
- Machine identification
- Fixture identification
- Gap between coil or inductor and part surface unless controlled by fixturing
- Power supply used

- Quenching procedure (spray, immersion, air blast, or other); where this involves special tools, the tool numbers or other description shall be included
- Settings, and if applicable, tolerances on settings, on all variables that are controlled by or can be changed by the operator of the equipment
- Tempering temperature and time

3.2.1 Variations or tolerances on settings, such as for on-time or power settings, are not permitted unless demonstrated to be acceptable by destructive examination of the results of such variations.

3.2.2 Coil changeovers on production lots shall be considered a new setup. Procedure qualification shall be demonstrated as required for a new coil.

3.3 Processing

3.3.1 Hardening

Hardening shall be accomplished by induction hardening as stated in the documented process and control procedures noted in 3.2.

3.3.2 Tempering

3.3.2.1 Tempering shall meet the requirements of AMS2759/1, AMS2759/2, or AMS2759/5 as applicable.

3.3.2.2 Tempering shall be documented in the process and control procedures noted in 3.2.

3.3.2.3 After hardening, parts shall be tempered within a time sufficient to prevent part cracking, but the time lapse after completion of the hardening operation shall not exceed 4 hours. Tempering temperature shall be selected to attain the specified properties of the part, including the case, but shall be at least 300 °F (149 °C).

3.4 Detail Requirements

3.4.1 Induction hardened parts shall meet specified requirements. Methods and terminology for indicating induction hardening patterns or zones are given in ARP4715.

3.4.2 There shall be no evidence of arcing or other electrical contact.

3.4.3 Parts shall be free from loose scale, but temper colors are permitted.

3.4.4 Average grain size in the hardened zone shall not increase by more than two sizes as determined in accordance with ASTM E112.

3.4.5 Except for the heat-affected zone there shall be no evidence of hardening or tempering in areas of the part that are not designated to be induction hardened, other than that which may have been required by prior hardening and tempering.

3.4.6 Hardness, when specified, shall be performed in accordance with ASTM E18 or ASTM E384

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection

Since induction hardening is strongly geometry and part specific, the purchaser of induction hardening services shall supply all samples for processors tests. The processor shall be responsible for the performance of all tests. Simulated parts for the destructive tests of 4.3 may be used if specifically approved by the cognizant engineering organization (see 8.2). The purchaser and cognizant engineering organization reserve the right to sample and to perform any confirmatory testing deemed necessary to ensure that the product conforms to the specified requirements.

4.2 Classification of Tests

4.2.1 Acceptance Tests

4.2.1.1 Class 1

All detail requirements (see 3.4) of this specification are acceptance tests and shall be performed on each lot of parts.

4.2.1.2 Class 2 and Class 3

When specified, hardness of both hardened zone and base metal, and tests for extent of hardening pattern or zone on the surface of the part, are acceptance tests and shall be performed on each lot of parts.

4.2.2 Preproduction Tests

All technical requirements of this specification and depth of hardened zone are preproduction tests and shall be performed for each new part number and whenever there is any change in coil or inductor, power supply, fixtures, or quench methods.

4.3 Sampling and Testing

A lot is a group of parts, all of the same part number, processed through the same equipment using the same parameters without breakdown of the setup within a period of 24 hours of each other and are presented to inspection at the same time. Testing shall be accomplished at the frequencies defined below unless another test frequency is specified by cognizant quality organization.

4.3.1 Class 1

4.3.1.1 One part per lot shall be destructively examined for conformance to all requirements of this specification and the specified hardening pattern or zones. When the lot size exceeds 50 parts, the frequency shall be one part for each 50 parts or fraction thereof.

4.3.1.2 Each part selected per 4.3.1.1 shall be tested on the part surface for hardness of the unaffected base metal and the hardness of the hardened zone.

4.3.1.3 Each part selected per 4.3.1.1 shall be tested to determine the extent of the induction hardened pattern or zone at the surface of the part.

4.3.2 Class 2

4.3.2.1 One part from each lot shall be destructively examined for conformance to all requirements of this specification and the specified hardening patterns or zones. However, a modified sampling plan may be used to accommodate very small (less than 50 parts) yet multiple lots, which do not involve a change in setup. In these instances, the destructive test frequency may be reduced to one part per 50, ignoring how many lots are involved.

4.3.2.2 Parts selected at random from the lot shall be tested for hardness in the unaffected base metal and the hardness of the induction hardened zone at the surface of the part at the frequency shown in Table 1.

4.3.2.3 Parts selected at random from the lot shall be tested for the extent of hardened zone at the frequency shown in Table 1.

4.3.3 Class 3

4.3.3.1 The first and, if the lot exceeds 50 parts, the last part, shall be destructively examined for conformance to the requirements of this specification and the specified requirements.

4.3.3.2 Parts selected at random from the lot shall be tested for hardness in the unaffected base metal and the hardness of the induction hardened zone at the frequency shown in Table 1.

4.3.3.3 Parts selected at random shall be tested for the extent of hardened zone at the frequency shown in Table 1.

Table 1 - Frequency of test for Class 2 and Class 3 parts

Number of Parts in Lot	Number of Class 2 Parts Tested in Each Lot	Number of Class 3 Parts Tested in Each Lot
Up to 7	All	2
8 to 15	7	4
16 to 40	10	4
41 to 100	15	5
101 to 300	25	6
301 to 500	35	7
501 to 700	50	8
Over 700	75	10

4.3.4 Destructive Testing

4.3.4.1 Destructive testing shall consist of examination of sufficient metallographically prepared cross sections to completely characterize the hardness and extent and depth of the hardened zone, the intermediate transition or heat affected zone(s), and the base metal. All dimensions of the various specified zones shall be measured.

4.3.4.2 Destructive examination shall include hardness traverses at appropriate intervals, or hardnesses taken at specific locations sufficient to assure that specified requirements are met. Hardness measurements shall be in accordance with ASTM E384.

4.3.4.3 Metallographically prepared cross-sections shall be etched to indicate and assure that the boundaries of the hardened zones in areas not specifically tested by hardness tests meet specified requirements.

4.3.4.4 Destructive examination shall assure that average grain size requirements are met.

4.3.5 Nondestructive Testing

4.3.5.1 Nondestructive testing on parts to determine the extent of hardened zone shall be performed by one of the methods given below unless another method is permitted by the cognizant quality or engineering organization. Test frequency shall be as shown in Table 1.

4.3.5.1.1 Temper etching as defined in AMS2649.

4.3.5.1.2 Grit or abrasive blasting to outline the differences between hardened and unaffected base metal.

4.4 Approval

4.4.1 The process and control procedures, or a preproduction part, or both, whichever is specified, shall be approved by the cognizant engineering organization before production parts are supplied (see 8.2).

4.4.2 Prior to making any changes to processes, coils or inductors, power supplies, quench methods, or controls, from those that approval was based the processor shall obtain authorization from the cognizant engineering organization. A significant change is one which, in the judgment of the cognizant engineering organization, could affect the properties or performance of the parts.

4.4.3 Control factors shall include, but are not limited to, all of the applicable elements required for a documented procedure (see 3.2).