

Induction Hardening of Steel Parts

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 - High Integrity or Critical

Class 2 - Structural Quality

Class 3 - Wear Resistance

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

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 canceled and no superseding document has been specified, the last published issue of that document shall apply.

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SAE WEB ADDRESS:

<http://www.sae.org>

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AMS 2649 Etch Inspection of High Strength Steel Parts

AMS 2759 Heat Treatment of Steel Parts

ARP4715 Induction Hardening of Steel Components

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19248-2959.

ASTM E 18 Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials

ASTM E 92 Vickers Hardness of Metallic Materials

ASTM E 112 Determining the Average Grain Size

ASTM E 384 Microhardness of Materials

3. TECHNICAL REQUIREMENTS:

3.1 Equipment:

3.1.1 Induction heating equipment shall consist of the following:

3.1.1.1 A Suitable Power Supply: The relationship between frequency and depth of hardening is given in ARP4715.

3.1.1.2 Controls adequate to reproduce the power, ramp rates (if used), and power on-time from one part to the next.

3.1.1.3 An inductor coil, specifically identified with the part to be hardened.

3.1.1.4 A quench facility to adequately quench the part to the desired martensitically hardened state.

3.2 Documentation:

Induction hardening shall be accomplished using a procedure that has been demonstrated to produce the results required by the engineering drawing. The documented procedure shall contain, but is not limited to, the following:

Part number or other full description of the part

Description or type of base metal, if not defined by drawing

Condition of base metal prior to induction hardening

Whether post induction hardening machining is required, and, if so, minimum and 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 Tempering:

After hardening, parts shall be tempered within a time sufficient to prevent part cracking, but the time shall not exceed four hours after completion of the hardening operation. 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 the requirements of the engineering drawing. Methods and terminology for indicating induction hardening 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 Grain size in the hardened zone shall not increase by more than two sizes as determined in accordance with ASTM E 112.

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.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for Inspection:

The vendor of induction hardening services shall supply all samples for vendor's tests and shall be responsible for the performance of all tests (See 8.6). Where actual or simulated parts are required for destructive examination, such parts shall be supplied by the purchaser. Purchaser reserves 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 requirements 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 on the surface of the part, are acceptance tests and shall be performed on each lot of parts.

4.2.2 Preproduction Tests: Tests for all technical requirements of this specification and for 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 shall be all parts of the same part number produced in the same equipment using the same parameters without breakdown of the setup or changes in parameters. Testing shall be accomplished at the frequencies defined below unless another test frequency is specified by purchaser.

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 hardening pattern or zones required by the engineering drawing. 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 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 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 hardening patterns or zones required by the engineering drawing. However, a modified sampling plan may be used to accommodate very small (less than 50 parts) yet multiple lots, that 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 hardness 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 requirements of the engineering drawing.

4.3.3.2 Parts selected at random from the lot shall be hardness 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.

4.3.4 Hardness testing shall conform to ASTM E 18 or ASTM E 92.

4.3.5 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 zones as required by the engineering drawing shall be measured.

4.3.5.1 Destructive examination shall include hardness traverses at appropriate intervals, or hardnesses taken at specific locations sufficient to assure that drawing requirements are met. Hardness measurements shall be in accordance with ASTM E 384.

4.3.5.2 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 drawing requirements.

4.3.5.3 Destructive examination shall assure that grain size requirements are met.

4.3.6 Non-destructive 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 purchaser. Test frequency shall be as shown in Table 1.

4.3.6.1 Temper etching as defined in AMS 2649.

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

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

4.4 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.

4.4.2 The supplier shall make no significant changes to processes, coils or inductors, power supplies, quench methods, or controls, from those upon which approval was based, unless the change is approved by 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).