Designation: A 986/A 986M – 01 (Reapproved 2006)

Standard Specification for Magnetic Particle Examination of Continuous Grain Flow Crankshaft Forgings[1]

This standard is issued under the fixed designation A 986/A 986M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the magnetic particle examination of forged continuous grain flow (CGF) crankshafts intended for medium speed diesel engines.

1.2 For the purpose of magnetic particle indication assessment, the crankshaft is divided into four zones of decreasing operational stress. Acceptance criteria have been set for each zone.

1.3 The engines to which these crankshafts are fitted are commonly used for diesel electric locomotives, marine propulsion, and power generation. Engines fueled by natural gas also fall into this medium speed category.

1.4 Specification A 983/A 983M is a product specification that covers the manufacture of CGF crankshafts.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

2. Referenced Documents

2.1 *ASTM Standards:* [2]

A 788/A 788M Specification for Steel Forgings, General Requirements

A 966/A 966M Test Method for Magnetic Particle Examination of Steel Forgings Using Alternating Current

A 983/A 983M Specification for Continuous Grain Flow Forged Carbon and Alloy Steel Crankshafts for Medium Speed Diesel Engines

3. Ordering Information

3.1 Specification A 983/A 983M requires that crankshafts made to that specification be examined in accordance with Specification A 986/A 986M for magnetic particle examination. It is the responsibility of the purchaser to specify any changes to the zone allocations for the crankshaft surfaces.

4. Procedure

4.1 Magnetic particle examination shall be conducted in accordance with Test Method A 966/A 966M. The use of prod type contacts is not permitted on finished crankshaft surfaces. Magnetic leeches may be used only on flat noncritical surfaces, and within the limitations specified in Test Method A 966/A 966M.

4.2 The magnetic particle examination shall be conducted using the wet fluorescent method described in Test Method A 966/A 966M.

5. Areas of Examination

5.1 *Zone 1—Major Critical Areas*:

5.1.1 *Crankpin Journals*—The major critical area of each crankpin journal shall include that area ±60 from the 6 o'clock position of the crankpin and extend ⅜ in. [10 mm] above the fillet collar and ⅝ in. [15 mm] along the crankpin surface as measured from the blend of the fillet radius and the journal surface. These positions are shown in Fig. 1.

5.1.2 *Main Bearing Journals*—The major critical areas of any main bearing journal shall include that area ±60 from the 12 o'clock position on top of the journal and extend ⅜ in. [10 mm] above the fillet collar and ⅝ in. [15 mm] along the journal as measured from the blend of the fillet radius and the journal surface. These positions are shown in Fig. 1.

5.1.3 *Oil Holes*—The major critical areas in also shall include the surfaces surrounding the journal oil holes. The diameter of this critical area shall be 3d, where d is the oil hole diameter before the radius. The critical area shall be centered on the centerline of the oil hole. In addition, the Zone 1 critical area shall extend down the oil hole for a distance from the journal surface equal to the hole diameter.

5.2 *Zone 2—Minor Critical Areas*:

[1] This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.06 on Steel Forgings and Billets.

Current edition approved March 1, 2006. Published April 2006. Originally approved in 1998. Last previous edition approved in 2001 as A 986/A 986M – 01.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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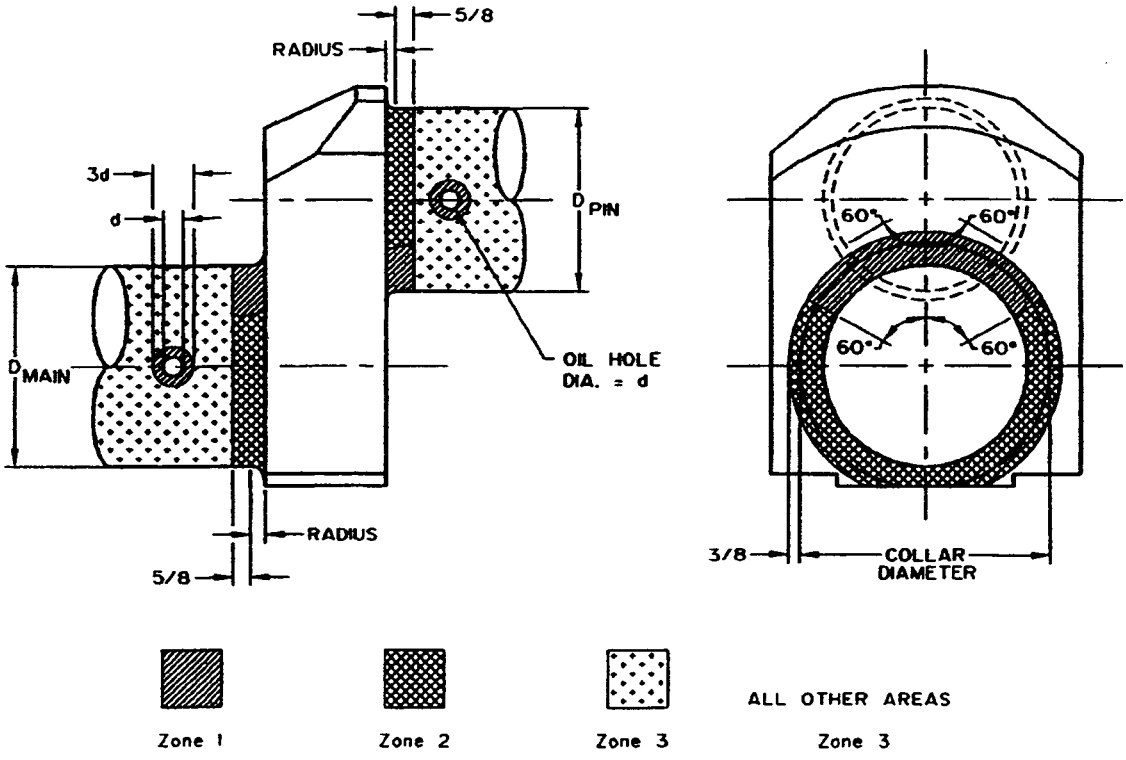

FIG. 1

5.2.1 The Zone 2 minor critical areas shall include the balance of the fillet radii of the crankpin and main bearing journals not included in the major critical areas.

5.2.2 When counterweights are attached to the crankshaft webs by welding, the weld surfaces and ½ in. [13 mm] of the adjacent surfaces shall be considered minor critical areas.

5.3 *Zone 3—Journal Running Surfaces*:

5.3.1 Zone 3 includes the remainder of the crankpin and main bearing journal surfaces not covered by the major and minor critical areas.

5.3.2 Zone 3 also includes the bearing journal surfaces for auxiliary drives, gear fit surfaces, keyways, and coupling flange radii.

5.4 *Zone 4—All Other Areas*:

5.4.1 Zone 4 includes the crankpin web surfaces, excluding areas covered by the major and minor critical areas, flange faces and periphery, and any other surfaces not included in Zones 1, 2, or 3.

6. Classification of Indications

6.1 Surface magnetic particle indications shall be classified as open or non-open.

6.1.1 Open indications are defined as those being visible after removal of the magnetic particles under a minimum 5 times optical magnification.

6.1.2 Non-open indications are not visible after removal of the magnetic particles.

7. Acceptance Criteria

7.1 *Zone 1*:

7.1.1 Indications are not permitted and must be removed by grinding or polishing. The original shape of the fillet must be maintained, when indications have been removed. The blended area shall not be deeper than 0.006 in. [0.15 mm] below the minimum drawing fillet dimension for the location.

7.1.2 The total area blended at less than the relevant minimum dimension shall not exceed 5 % of the major critical area of the particular crankpin or main bearing fillet or designated surface at an oil hole.

7.2 *Zone 2*:

7.2.1 Open indications are not permitted and must be removed. The depth of the resulting depression shall not exceed 0.010 in. [0.25 mm] below the minimum fillet dimension for the location. The total area of depressions or dimples in a Zone 2 fillet shall not exceed 5 % of the Zone 2 fillet area.

7.2.2 Non-open indications are permitted up to a maximum length of 2 % of D, where D is the diameter of the journal in question. The maximum total length of non-open indications in a Zone 2 fillet location shall not exceed 0.75 in. [20.0 mm], and the individual indications must be separated from each other by a minimum length of 2 % of D.

7.2.3 Non-open indications exceeding the length limitations of 7.2.2, either individually or in total, may be dimpled to a maximum depth of 0.010 in. [0.25 mm] below the minimum drawing dimension, but the aggregate length and area limitations of 7.2.1 and 7.2.2 shall apply.

7.2.4 The combined dimple areas in any main or crankpin journal fillet shall not exceed 8 % of the total fillet area.

7.2.5 For welds attaching counterweights to crankshaft webs, the following acceptance criteria apply.

7.2.5.1 The surfaces to be examined shall be prepared to give a surface finish of at least 250 µin. [6.35 µm]

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7.2.5.2 Linear indications shall not exceed 1/32 in. [1 mm] in length in the weld areas of the counterweight sides (posts). Indications exceeding this size shall be ground to a maximum depth of 1/8 in. [3 mm] below the minimum weld dimension and re-examined. If the indication has been removed, or reduced to an acceptable length, the resulting dimple shall be blended to transition smoothly with the surrounding surface. If the indication is still unacceptable in length, it shall be removed completely and the area restored by welding in accordance with the qualified welding procedure.

7.2.5.3 The end faces and corners of the counterweight welds, and 1 in. [25 mm] along each side extending from the corners shall exhibit no indications. Any indications shall be removed by grinding, and the resulting dimple shall not exceed 3/16 in. [5 mm] in depth below the minimum weld dimension, and 1/2 in. [13 mm] in length. If the dimple extends beyond these dimensions, the area shall be repair welded in accordance with the qualified procedure. If more than 1/4 in. [6 mm] of stock is removed from any weld corner, the area shall be restored by repair welding, again in accordance with the qualified procedure.

7.3 *Zone 3*:

7.3.1 Open indications not exceeding 0.20 in. [5.0 mm] in length individually in any one Zone 3 location, provided that the total length does not exceed 0.50 in. [13.0 mm] in any 1 in.^{2} [650 mm^2] of surface area.

7.3.2 Open indications in excess of 0.20 in. [5.0 mm] in length may be removed by dimpling to a maximum depth of 0.010 in. [0.25 mm] below the minimum drawing dimension for the location. The area of the resulting dimples shall not exceed 3 % of the Zone 3 location area.

7.3.3 Non-open indications exceeding 0.20 in. [5.0 mm] in length are considered to be relevant. Relevant indications exceeding the greater of 0.5 in. [13.0 mm] or 6 % of D, where D is the diameter of the journal in question, are unacceptable, but may be reduced to an acceptable length by dimpling to a depth not to exceed 0.010 in. [0.25 mm]. The total length of relevant non-open indications in any one Zone 3 location shall not exceed 2.0 in. [50 mm].

7.4 *Zone 4*:

7.4.1 Open indications exceeding 0.25 in. [6.0 mm] are considered to be relevant, and the total length of such indications in any one Zone 4 location shall not exceed 1.0 in. [25 mm]. Open indications, regardless of length, separated by less than 1/8 in. [3 mm] shall be considered to be a single indication.

7.4.2 Dimpling of relevant open indications may be done to meet the requirements of 7.4.1 up to a maximum depth of 0.25 in. [5.0 mm].

7.4.3 Non-open indications not exceeding 1.0 in. [25.0 mm] in length are acceptable, provided that the total length of indications exceeding 0.25 in. [6.0 mm] does not exceed 4.0 in. [100.0 mm] in any 25 in.^{2} [16 000 mm^2] area.

7.4.4 Dimpling of non-open indications to a maximum depth of 0.40 in. [10.0 mm] in a particular Zone 4 location may be done to bring the length limitation requirements into compliance with 7.4.3.

8. Dimpling

8.1 To dimple means to stone or grind to remove stock in an area that contains an unacceptable indication. In order to minimize stress concentrations, all dimples shall have a bottom radius of approximately three times the dimple depth, and shall be smoothly blended to the surface area. The finish in the dimple shall be at least equal to that of the adjacent surface.

8.2 When making a dimple in a surface to remove a visual or magnetic particle indication, care must be taken to avoid the unnecessary reduction in bearing surface on a bearing journal. When a crankshaft has been surface hardened by nitriding or induction hardening, caution must be exercised to avoid excessive penetration into the case, particularly in the critical areas.

9. Inspection

9.1 The requirements of Specification A 788/A 788M shall apply.

10. Rejection

10.1 The requirements of Specification A 788/A 788M shall apply.

11. Certification

11.1 The requirements of Specification A 788/A 788M shall apply.

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