

CONFIRMED
DECEMBER 2007

Specification for

Magnetic particle flaw inspection of finished machined solid forged and drop stamped crankshafts

UDC 621.824.3:669.14 – 134:620.19:620.179.14

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW



Document Sharing Hub

Co-operating organizations

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and professional and industrial organizations:

Associated Offices Technical Committee	Department of Trade and Industry, National Engineering Laboratory
Association of Consulting Engineers	Electricity Supply Industry in England and Wales
Association of Hydraulic Equipment Manufacturers Ltd	Engineering Equipment Users' Association
Association of Mining Electrical and Mechanical Engineers	Federation of Manufacturers of Construction Equipment and Cranes
British Compressed Air Society	Institution of Gas Engineers
British Electrical and Allied Manufacturers' Association*	Institution of Heating and Ventilating Engineers
British Gas Corporation	Institution of Mechanical Engineers
British Gear Manufacturers' Association	Institution of Plant Engineers
British Internal Combustion Engine Manufacturers' Association*	Institution of Production Engineers
British Mechanical Engineering Confederation	London Transport Executive
British Pump Manufacturers' Association	Machine Tool Trades Association
British Steel Corporation	Ministry of Defence*
British Steel Industry	Ministry of Defence, Army Department*
Crown Agents for Oversea Governments and Administrations	National Coal Board
Department of Employment (HM Factory Inspectorate)	Process Plant Association
Department of the Environment	Railway Industry Association of Great Britain
Department of Trade and Industry	Royal Institute of British Architects
	Telecommunication Engineering and Manufacturing Association

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard.

Diesel Engineers' and Users' Association	Society of Motor Manufacturers and Traders Ltd
--	--

This British Standard, having been approved by the Mechanical Engineering Industry Standards Committee, was published under the authority of the Executive Board on 31 October 1974

© BSI 09-1999

The following BSI references relate to the work on this standard:
Committee reference MEE/123
Draft for comment 71/38107

ISBN 0 580 08138 9

Amendments issued since publication

Amd. No.	Date of issue	Comments
4439	December 1983	Indicated by a sideline in the margin

Contents

	Page
Co-operating organizations	Inside front cover
Foreword	ii
1 Scope	1
2 References	1
3 Method of test	1
4 Assessment of results	1
5 Inspection and rectification of defects	3
6 Certificate of test	3
Appendix A The effects of dimpling on crankshafts: results of an investigation on a known crankshaft	7
Figure 1 — Inspection zones: crankshaft in which the pin and journal does not overlap	4
Figure 2 — Inspection zones: crankshaft with overlap between pin and journal	5
Figure 3 — Permissible sizes of inclusions	6
Figure 4 — Bending stress distribution in the crankpin fillet of a typical crankshaft	10
Figure 5 — Torsional stress distribution in the crankpin fillet of a typical crankshaft	11
Figure 6 — Stress concentration factor against r/h in bending and torsion, showing minimum permitted values of r/h for a crankpin with a 360° groove	12
Figure 7 — Percentage reduction in load-carrying capacity of a crankshaft bearing	13
Figure 8 — Non-dimensional load-carrying capacity of a crankshaft bearing	14
Table 1 — Maximum equivalent median stress ($\alpha = 30^\circ \theta = 0^\circ$)	7
Table 2 — Maximum equivalent semi-range alternating stresses ($\alpha = 30^\circ \theta = 0^\circ$)	7
Table 3 — Maximum equivalent median stress	8
Table 4 — Maximum equivalent semi-range alternating stresses	8
Publications referred to	Inside back cover

Foreword

This British Standard has been prepared under the authority of the Mechanical Engineering Industry Standards Committee.

The use of the magnetic particle technique for the inspection of crankshafts has increased. This British Standard defines the criteria for acceptance of finished machined solid forged crankshafts.

A survey has been made of the results of investigations carried out on crankshafts and bearings which have failed in service. Few reported failures were attributed to major material defects or to the presence of non-metallic inclusions. Similarly, another survey has revealed evidence of satisfactory bearing performance on crankshafts which have been dimpled and, in some cases, these dimples were beyond the limits stated in this standard.

Stress distributions in various crankshaft designs have been taken into account in the preparation of this standard to ensure that the permitted defects do not give rise to stresses in excess of the intended maximum values.

Appendix A gives the results of an investigation made on the effects of dimpling on a known crankshaft. This is based on information available at the time of preparation of this standard. Subsequent photo-elastic analysis of specific dimple profiles has confirmed that the requirements in this standard are of a conservative nature¹⁾.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

¹⁾ See the following:

DIVER P and HESSLER H. Stress concentrations at dimples in crankshafts.

Journal of strain analysis, Vol 9, No. 2. Institution of Mechanical Engineers, 1974.

1 Scope

This standard specifies the conditions for the magnetic particle flaw inspection of solid forged and drop stamped crankshafts with pin or journal finished machined diameter of 80 mm and over, excluding built-up shafts and automotive types. It also specifies levels for acceptance and for local removal of defects.

This British Standard is applicable to any shaft proportioned in accordance with the rules of Lloyd's Register of Shipping.

2 References

The titles of the British Standards referred to in this standard are listed on the inside back cover.

3 Method of test

3.1 The surface condition of the crankshaft or of parts under examination shall be such that there is no interference with the test. All areas to be examined shall be free from dirt, grease or paint or any other foreign matter which may interfere with the application of the test.

3.2 The crankshaft shall be magnetized to reveal both longitudinal and transverse defects.

3.3 Great care shall be taken when applying the contacts to ensure that these are not applied in critical areas and that scorch or burn marks are avoided. Where crankshafts are too large to be magnetized by other methods, prods may be used only by agreement with the engine builder and the Inspecting Authority. The prods shall be designed to give the largest possible contact area, and special care shall be taken to ensure cleanness in order that good electrical contact is achieved. Where contacts or prods are used to magnetize they shall be applied only to zone 4 areas (see Figure 1 and Figure 2).

3.4 The continuous wet method of magnetic flaw detection shall be used wherein a suspension of fine magnetic particles in paraffin or similar medium is applied whilst the current is flowing. The magnetic ink used shall comply with the requirements of BS 4069.

3.5 Magnetization shall be generally in accordance with the requirements of BS 6072.

3.5.1 Where the current is fed into the ends of the crankshaft, the current strength shall be not less than 5 300 A/m of diameter for a.c. (r.m.s. value) or 7 500 A/m of diameter for d.c. or a.c. peak value.

3.5.2 Where prods are used, the distance between them shall be normally 200 ± 20 mm. With prods at a distance apart of 200 mm, the current strength shall be not less than 600 A (a.c. r.m.s. value) or 850 A (d.c. or a.c. peak value).

Where it is necessary to use prods at less than 200 mm apart, the current strength may be reduced in direct proportion to the distance between the prods.

The positioning of the prods between successive checks shall be staggered to provide a minimum overlap of half the distance apart in a longitudinal direction and quarter the distance apart in a lateral direction.

3.5.3 The use of a magnetic field strength meter is recommended and will ensure that the technique employed provides an adequate field strength. Generally a magnetic field strength of not less than 2 400 A/m is required.

3.5.4 The use of excessive field strengths shall be avoided, as micro-structural and segregation effects may be over-emphasized. In addition, magnetic saturation causing the build up of particles on the edges and corners of the crankshaft shall not be allowed to occur.

3.6 If specified by the purchaser, the crankshaft shall be adequately demagnetized after tests.

3.7 On completion of the test, the crankshaft shall be thoroughly cleaned and protected against corrosion.

4 Assessment of results

Isolated inclusions less than 0.5 mm long should be ignored. For the assessment of results the crankshaft shall be divided into four zones as shown in Figure 1 and Figure 2.

NOTE For the purpose of this standard, dimples may be hemispherical, longitudinal, transverse or at any intermediate angle.

4.1 Zone 1

4.1.1 Permissible indications. Defects in this zone are acceptable only if they can be rectified in accordance with the requirements of 4.1.2.

4.1.2 Other indications. Surface defects in the fillet radius only may be removed, except in the case of fillet rolled crankshafts, by local grinding, provided a large arc of the fillet is smoothed away so that no local depressions remain and provided the fillet does not lose its specified form. Defects in the mouth of the lubricating oil holes may be removed, provided the radius of curvature of the ground newly formed surface is not less than that of the oil hole.

The depth of metal removed shall not exceed 1 % of the adjacent bearing diameter.

4.1.3 In other areas of zone 1, no rectification is permitted, except with the approval of the engine builder and any Inspecting Authority concerned.

4.2 Zone 2

4.2.1 Permissible indications. In the fillet radius and adjacent surface of the pin or journal, well dispersed non-metallic inclusions are acceptable provided that they are in a substantially longitudinal direction (parallel to the shaft axis) and that the length of the individual inclusions does not exceed the value given in Figure 3.

In the crankweb surfaces non-metallic inclusions are acceptable, irrespective of direction, provided they are reasonably dispersed and that the length of individual inclusions does not exceed the value given in Figure 3.

The total length of non-metallic inclusions in each fillet area, plus those in the appropriate part of the crankweb, shall not exceed three times the individual maximum length given in Figure 3 and subject to 5.8, ignoring those inclusions that are less than 20 % of maximum permitted length.

4.2.2 Other indications. Non-metallic inclusions falling outside the permitted limits and other surface defects are unacceptable. Surface defects in the fillet radius may be removed, except in the case of fillet rolled crankshafts, provided that:

- a) a large arc of the fillet is smoothed away so that no local depressions remain;
- b) the fillet does not lose its specified form;
- c) the depth of the metal removed does not exceed 1 % of the adjacent bearing diameter.

Rectification of defects on the surface of the crankwebs shall be in accordance with 5.9 and the dimple shall be not deeper than 1 % of the adjacent bearing diameter. The dimple length shall not exceed 5 % of the adjacent bearing diameter and the total length of all such dimples on any crankweb shall not exceed three times the permitted individual length.

4.2.3 In other areas of zone 2, no rectification is permitted except with the approval of the engine builder and any Inspecting Authority concerned.

4.3 Zone 3

4.3.1 Permissible indications. Non-metallic inclusions are acceptable, provided that the length of individual inclusions does not exceed the value given in Figure 3, and that the inclusions are in a substantially longitudinal direction and are reasonably dispersed. The total length of such defects in each bearing surface shall not exceed three times the permitted maximum individual length specified in Figure 3 and subject to 5.8, ignoring those inclusions that are less than 20 % of maximum permitted length.

4.3.2 Other indications. Non-metallic inclusions falling outside the permitted limits, and other surface defects are not acceptable. Surface defects may be removed by local dressing (dimpling) provided that:

- a) the length of any single dimple does not exceed 5 % of the bearing diameter;
- b) the depth of the dimple shall not exceed 1 % of the bearing diameter;
- c) the profile of the dimple is in accordance with the form stated in 4.9;
- d) there are no more than two dimples on any one crankpin or journal surface and the length of the bearing surface between dimples is not less than 4 % of the bearing diameter.

4.3.3 The limitations in 4.3 may only be exceeded by agreement between the purchaser and the manufacturer.

4.4 Zone 4

4.4.1 Permissible indications. Non-metallic inclusions are acceptable irrespective of direction provided their length does not exceed the value given in Figure 3.

The total length of non-metallic inclusions allowed in each crankweb may be up to 30 % of the journal diameter, provided that these indications are dispersed and subject to 5.8, ignoring those inclusions that are less than 20 % of maximum permitted length.

4.4.2 Other indications. Non-metallic inclusions falling outside the permitted limits, and other surface defects are not acceptable. Surface defects may be removed by local dressing provided that:

- a) the depth of any single dimple is less than 2 %;
- b) the length is less than 12 % of the journal diameter;
- c) the profile of the dimple is in accordance with 5.9.

Where several defects are ground away in any one crankweb, the total area ground off shall not exceed twice that permitted for a single groove.

4.4.3 The limitations in 4.4 may only be exceeded by agreement between the purchaser and the manufacturer.