INTERNATIONAL STANDARD

ISO 4386-1

Second edition
1992-02-15

Plain bearings — Metallic multilayer plain bearings —

Part 1:

Non-destructive ultrasonic testing of bond

Paliers lisses — Paliers lisses métalliques multicouches —

Partie 1: Contrôle non destructif aux ultrasons des défauts d'adhérence

Reference number
ISO 4386-1:1992(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 4386-1 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Sub-Committee SC 2, *Materials and lubricants, their properties, characteristics, test methods and testing conditions*.

This second edition cancels and replaces the first edition (ISO 4386-1:1982), which has been technically revised.

ISO 4386 consists of the following parts, under the general title *Plain bearings — Metallic multilayer plain bearings*:

— *Part 1: Non-destructive ultrasonic testing of bond*

— *Part 2: Destructive testing of bond for bearing metal layer thicknesses greater than or equal to 2 mm*

— *Part 3: Non-destructive penetrant testing*

Annex A of this part of ISO 4386 is for information only.

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Plain bearings — Metallic multilayer plain bearings —

Part 1:
Non-destructive ultrasonic testing of bond

1 Scope

This part of ISO 4386 specifies an ultrasonic testing method for determining bond defects between the bearing metal and the backing. The test can be performed on metallic multilayer plain bearings consisting of backings lined with bearing metal based on lead and tin, with layer thicknesses greater than or equal to 0,5 mm.

The test is not possible within half the diameter of the crystal from the edges of the bearing, oil holes, grooves, etc. because of undefined reflections. In bearings with dovetail keying grooves at the bond, the test may not be possible along the edges of the dovetails. Evaluation of the bond between the bearing backing and bearing material on the end faces and joint faces is possible by the penetrant testing method specified in ISO 4386-3.

Within the meaning of this part of ISO 4386, the ultrasonic method only permits a qualitative evaluation of the bonding and not a quantitative determination of the bond strength as specified in ISO 4386-2.

This part of ISO 4386 only describes in detail the pulse-echo method in which the probe is applied from the bearing metal side. When the probe is applied from the backing side, the signals are to be treated analogously.

The sound energy reflected by the bond surface area between the bearing metal and the backing is used to determine the quality of the bonding.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 4386. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 4386 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2400:1972, *Welds in steel — Reference block for the calibration of equipment for ultrasonic examination.*

ISO 4386-2:1982, *Plain bearings — Metallic multilayer plain bearings — Part 2: Destructive testing of bond for bearing metal layer thicknesses greater than or equal to 2 mm.*

ISO 4386-3:1992, *Plain bearings — Metallic multilayer plain bearings — Part 3: Non-destructive penetrant testing.*

ISO 7963:1985, *Welds in steel — Calibration block No. 2 for ultrasonic examination of welds.*

3 Symbols

The following symbols are used on the figures in this part of ISO 4386.

IS	Input signal
BE	Bond echo
WE	Back-wall echo
RE	Reference echo

4 Test equipment

4.1 Ultrasonic test device

Pulse-echo ultrasonic flaw detection equipment using rectified A-scope presentation shall be used for the test. The equipment shall be fitted with a calibrated attenuator, reading in decibels, and adjustable time base ranges. Suppression and swept-gain functions shall be switched off.

4.2 Probes

The size, frequency and type of probe shall be chosen in relation to the thickness of the bearing layer, backing thickness and backing material. See table 1.

In the case of thin linings, where the input signal and bond echo cannot be shown separately on the screen, it is necessary to use twin-crystal probes with higher frequency for the thinnest lining.

4.3 Time base range

The time base range shall be adjusted so that at least two bond echoes are obtained from a suitable reference block. This reference block shall consist of a layer of bearing metal, part of which is correctly bonded and part of which is incorrectly bonded on a backing material. The materials used in the reference block and the thicknesses shall be the same as in the bearing to be inspected.

5 Preparation

5.1 Preparation of test surface (sliding surface)

5.1.1 Condition of test surface

The test surface shall have a surface roughness of $R_a \leqslant 5$ µm.

5.1.2 Cleaning of test surface

After machining, remove dirt and oil using suitable cleaning agents. When necessary, the surface may be dried using cleaning paper or rags.

5.2 Ultrasonic scanning

Test plain bearings using either contact scanning with light machine oil as a couplant, or using immersion scanning. Bearings with smaller diameters may be difficult to inspect by contact scanning since uniform coupling may be difficult to achieve on the curved surface.

Coupling may be improved by selecting a probe manufactured with a curved surface which approximately conforms to the radius of the surface. Alternatively, and specifically for bearings less than 100 mm in diameter, contact scanning from the back surface may be used where the back surface is smooth (see 5.1.1). Scanning from the back surface may also be used for further examination of defects if signals from the bearing metal surface are inconclusive, due, for example, to defects within the thickness of the backing material.

Table 1 — Choice of probe

Bearing metal layer thickness mm	Backing thickness (steel)[1)] mm	Probe diameter mm	Probe frequency MHz	Probe type
> 2	20 to 250	10 to 30	2 to 5	Single crystal
1 to 3	5 to 50	10 to 15	4 to 6	Twin crystal
0,5 to 3	1 to 25	6	10	Twin crystal

1) For cast iron, the maximum is reduced by the factor 0,5; for bronze, by the factor 0,3 to 0,2.

6 Test classes

The test may be carried out in accordance with one of the following three classes, which are of increasing severity.

— **Class 1:** complete coverage of the edge zones of the sliding surface at flange sides and joint areas; point-type coverage of the sliding surface.

— **Class 2:** complete coverage of the flange surfaces, the edge zones of the sliding surface at flange sides and joint areas. In addition, complete coverage of the area of maximum loading (for example, in the case of a radial bearing with a bearing force acting vertically downwards, this would be in the range from 60° to 120° with respect to the sliding surface).

— **Class 3:** complete coverage of the flange areas and sliding surface line-by-line with the probe. In order to cover all points, testing is done with an overlap of the lines of 20 % of the crystal diameter.

7 Defect groups

The choice of defect group depends of the strains to which the plain bearing is subjected when in operation. The design of the backing influences the manufacturing costs. This results in the following classification of the defect groups (see table 2).

— **Defect group A:** applicable to the new manufacture of plain bearings with steel backings having a wall thickness up to 70 mm, without voids and bores and with no interruptions in the lined area. The variation of the wall thickness shall not exceed 25 %.

— **Defect groups B1 and B2:** applicable to the new manufacture of plain bearings with steel backings having a wall thickness up to 100 mm without voids and bores and with no interruptions in the lined area. The variation of the wall thickness shall not exceed 50 %.

— **Defect group C:** applicable to the new manufacture and repair of plain bearings with steel backings having a wall thickness up to 100 mm (if necessary, with voids, bores and interruptions in the lined area). The variation of the wall thickness shall not exceed 50 %.

— **Defect group D:** applicable to the new manufacture and repair of plain bearings which cannot be classified as belonging to defect groups A, B or C.

8 Testing

8.1 Back-wall echo testing

Always check the bond using one of the bond-echo and back-wall-echo comparison methods if these are permitted by the geometry of the multilayer plain bearing and by the material of the backing. The alternative methods are as given in 8.1.1 and 8.1.2.

8.1.1 Testing according to the relative height of the bond and back-wall echoes

When using probes complying with 4.2, the bond is good when the echo from the bond surface area (bond echo) is equal to or less than the back-wall echo (see figure 1).

If the bond echo is greater than the back-wall echo, then the bond between the bearing metal and backing is not adequate. If, further, there is no back-wall echo and the bond echo is repeated (at least three repeat echoes), then no bond is present (see figure 2). During the evaluation, both these results shall be treated as representing bond defects. If the bond and back-wall echoes are both reduced, or if the signal becomes diffuse, this indicates porosity within the bearing metal. If areas with porosity within the bearing metal border on defective bond areas, then these areas shall be regarded as defects due to the uncertainty of evaluation of the bond.

In the case of very thick-walled bearings of small diameter, or when using twin-crystal probes, the back-wall echo can become smaller than the bond echo because of a sound-beam divergence or a sound-wave weakening, even though the bond is good. If in doubt, the ratio between the levels of the two echoes of a perfect and a missing bond shall be determined using a reference piece (steel and bearing metal).

8.1.2 Testing according to the reduction in height of the back-wall echo

Calibrate the sweep of the test equipment using a reference block complying with ISO 2400 or ISO 7963 to obtain at least two back-wall echoes on the screen. Then adjust the amplification so that the first back-wall echo of the plain bearing to be tested reaches 80 % of the screen height. The position of the back-wall echo on the screen should be marked. Bond or backing material defects are then indicated by the position of intermediate echoes occurring before the first back-wall echo.

Then assess the severity of the defects by the reduction of the back-wall echo (see figures 3 and 4). An echo of 50 % screen height or less is deemed to indicate a significant defect during assessment of the bearing, in accordance with 8.2.

8.2 Testing without a back-wall echo

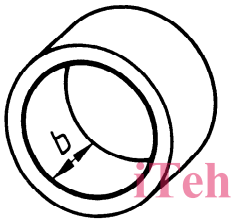
Evaluate the bond using a reference echo from a reference block. This block is made from solid lining metal approximately the thickness of the bearing metal lining. Adjust the reference echo to 80 % of the screen height (see figures 5 and 7; for a twin-crystal probe, see figures 9 and 11). The bond is good when the first bond echo is less than the reference echo (see figure 6; for a twin-crystal probe, see figure 10). A bond defect is present when the first echo from the bond zone is equal to or higher than the reference echo (see figure 8; for a twin-crystal probe, see figure 12).

If the signal becomes irregular or diffuse, this indicates porosity within the bearing metal.

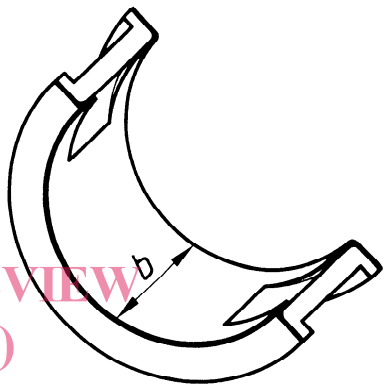
If areas with porosity within the bearing metal border on defective bond areas, then these areas shall be regarded as defects because of the uncertainty of evaluation of the bond.

Table 2 — Defect groups

Defect group	Bonding area[1] Single defect mm² max.	Bonding area[1] Total defect % max.	Edge zone[2] Defect related to the single edge length % max.	but not exceeding mm max.
A	0	0	0	0
B1	0,75*b*	1	1	5
B2	2*b*	1	1	5
C	2*b*	2	2	10
D	4*b*	5	4	20

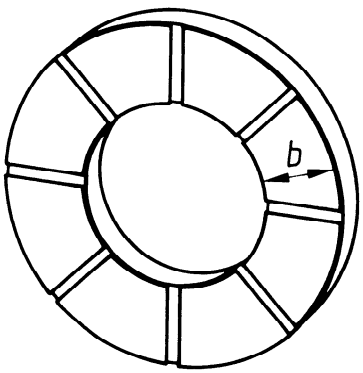


Bush

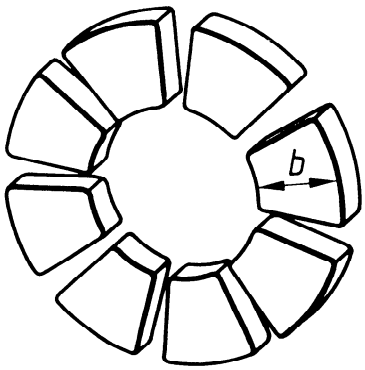


Bearing liner

a) Plain journal bearings



Thrust ring



Set of thrust pads

b) Plain thrust bearings

1) The bonding area is the entire continuous actual bonding area of a journal or thrust plain bearing element.

b, in millimetres, represents the functional width of the bearing in the case of journal bearing, and the width of the segment or ring in the case of thrust bearings.

If the single defect is greater than the total defect, then the total defect shall be used.

2) The edge zone is the visible transition from the backing to the bearing material. In the case of journal bearings or thrust bearings, the edge length is the edge zone of the plane face or the joint face. In the case of pad bearings or tilting pad bearings, the edge length is the peripheral length of one single pad.

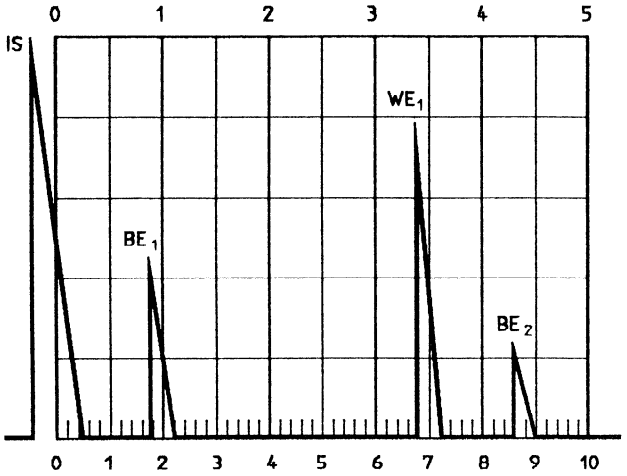


Figure 1 — Good bond

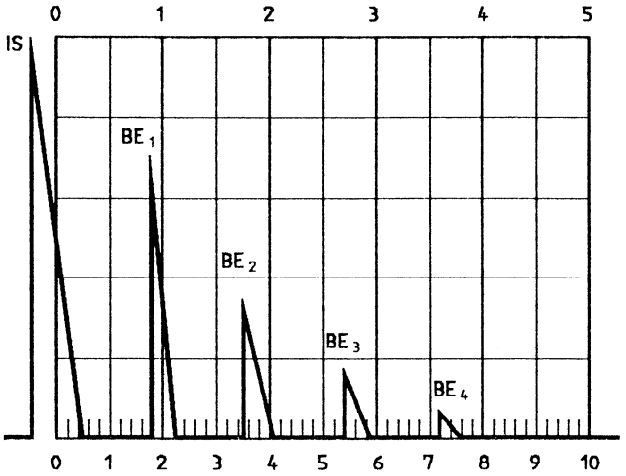


Figure 2 — No bond

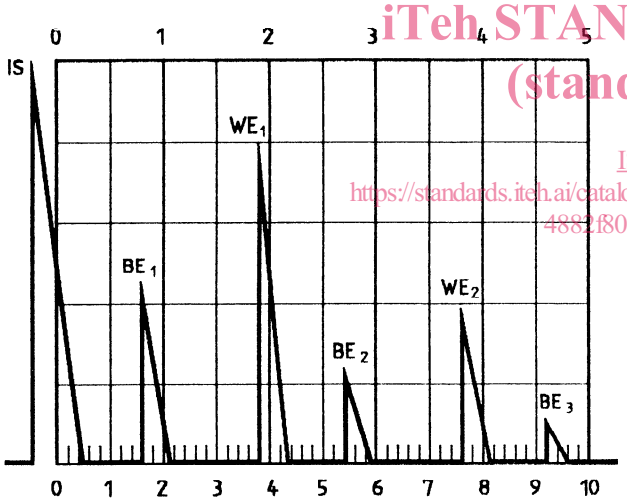


Figure 3 — Good bond

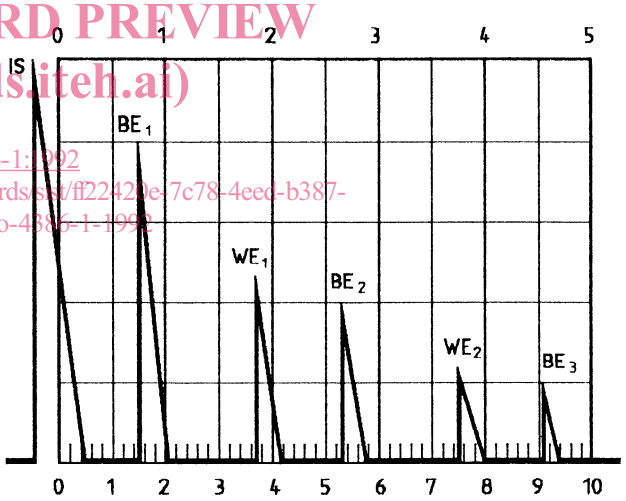


Figure 4 — Bad bond

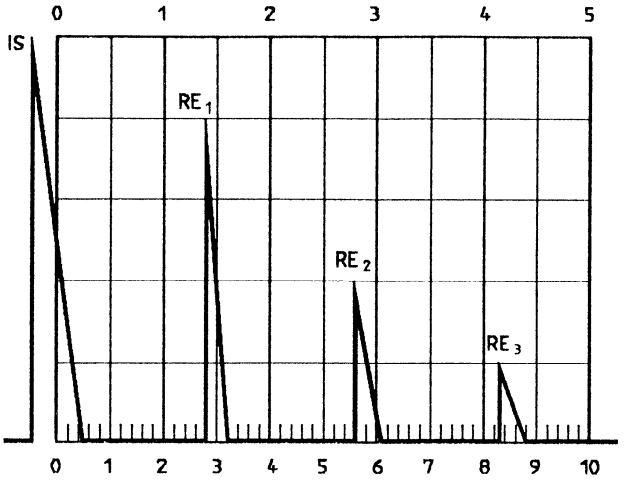


Figure 5 — Adjustment of the reference echo

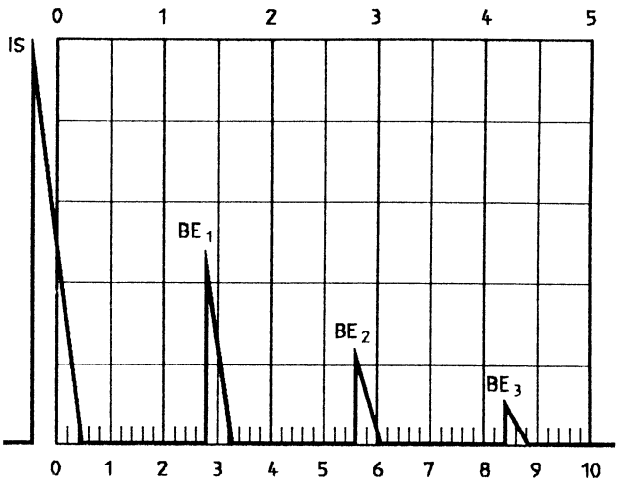


Figure 6 — Good bond

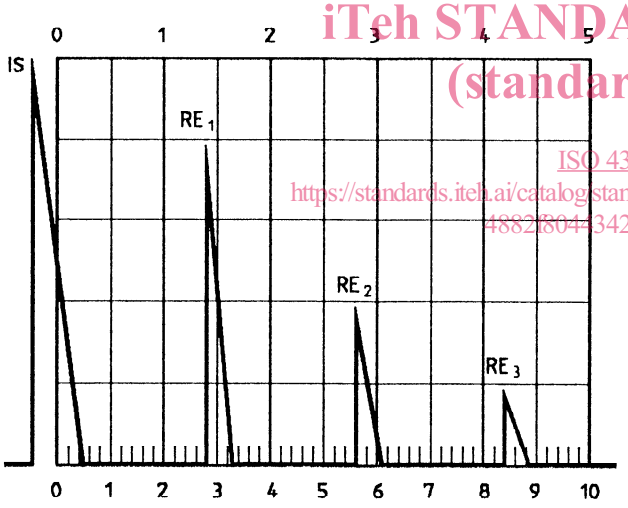


Figure 7 — Adjustment of the reference echo

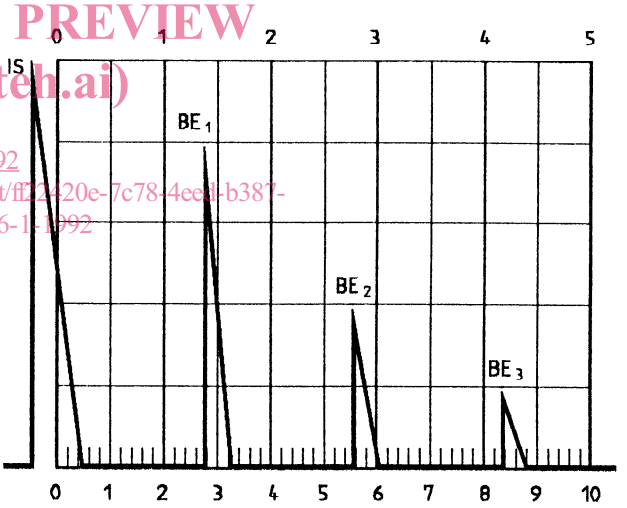


Figure 8 — Bad bond