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**Plain bearings — Bearing fatigue —**  
**Part 4:**  
**Tests on half-bearings of a metallic**  
**multilayer bearing material**

*Paliers lisses — Fatigue des paliers —*

*Partie 4: Essais sur demi-coussinets en matériau antifriction  
métallique multicouche*

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## 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see

This document was prepared by Technical Committee ISO/TC 123, *Plain bearing*, Subcommittee SC 2, *Materials and lubricants, their properties, characteristics, test methods and testing conditions*.

This second edition cancels and replaces the first edition (ISO 7905-4:1995), which has been editorially revised. The main changes compared to the previous edition are as follows:

- adjustments to ISO/IEC Directives, Part 2:2018 have been made;
- [Annex A](#) has been revised;
- the Bibliography has been revised.

A list of all parts in the ISO 7905 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

# Plain bearings — Bearing fatigue —

## Part 4:

## Tests on half-bearings of a metallic multilayer bearing material

### 1 Scope

This document specifies a method for the determination of the endurance limit in fatigue of half-bearings of multilayer bearing materials.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

### 3 Terms and definitions (standards.iteh.ai)

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

### 4 Symbols

The symbols used are given in [Table 1](#).

**Table 1 — Symbols**

Symbol	Description	Unit
$A_1$	coefficient of stress at the bearing backing	—
$a_{1,i}$	3 coefficients at the outside of the bearing back with $i = 0, 1, 2$	—
$A_2$	coefficient of stress at the surface of the lining	—
$a_{2,i}$	3 coefficients at the surface of the lining with $i = 0, 1, 2$	—
$b$	bearing width	mm
$B_1$	coefficient of stress at the bearing backing	—
$b_{1,i}$	3 coefficients at the outside of the bearing back with $i = 0, 1, 2$	—
$B_2$	coefficient of stress at the surface of the lining	—
$b_{2,i}$	3 coefficients at the surface of the lining with $i = 0, 1, 2$	—
$E$	Young's modulus	MPa
$E_1$	Young's modulus, steel bearing backing, $E_1 = 210 \cdot 10^3$	MPa
$E_2$	Young's modulus, lining	Pa

Table 1 (continued)

Symbol	Description	Unit
$E_2^*$	dimensionless Young's modulus, $E_2^* = E_2/E_{2,0}$	—
$E_{2,0}$	Young's modulus of bearing used to construct curves in <a href="#">Figure A.2</a> , $E_{2,0} = 50 \cdot 10^3$	MPa
$E_3$	Young's modulus, overlay	Pa
$F$	radial force	N
$\bar{r}$	radius of mean thickness $\bar{r} = (r_3 + r_4) \cdot 0,5$	mm
$r_2$	radius of interface between the bearing backing and lining	mm
$r_3$	radius of running surface (overlay thickness negligible)	mm
$r_4$	outer radius of bearing steel back	mm
$s$	total thickness of bearing	mm
$s^*$	dimensionless total thickness, $s^* = 2 \cdot [(r_4 - r_3)/(r_4 + r_3)]$	—
$s_1$	thickness of steel backing	mm
$s_1^*$	dimensionless steel backing thickness, $s_1^* = (r_4 - r_2)/(r_4 - r_3)$	—
$\sigma$	stress	Pa
$\sigma^*$	dimensionless stress, $\sigma^* = \sigma/\sigma_{\text{nom}}$	—
$\sigma_{\text{nom}}$	nominal stress, $\sigma_{\text{nom}} = (6 \cdot F \cdot \bar{r})/(b \cdot s^2)$	Pa
$\sigma_1$	stress at the outside of the bearing back	MPa
$\sigma_1^*$	dimensionless stress at the bearing steel back	—
$\sigma_2$	stress at the surface of the lining	MPa
$\sigma_2^*$	dimensionless stress, lining surface	—
$\sigma_3$	stress in overlay	Pa
$\nu_1$	Poisson's ratio, steel backing	—
$\nu_2$	Poisson's ratio, lining	—
$\nu_3$	Poisson's ratio, overlay	—

## 5 Test specimens

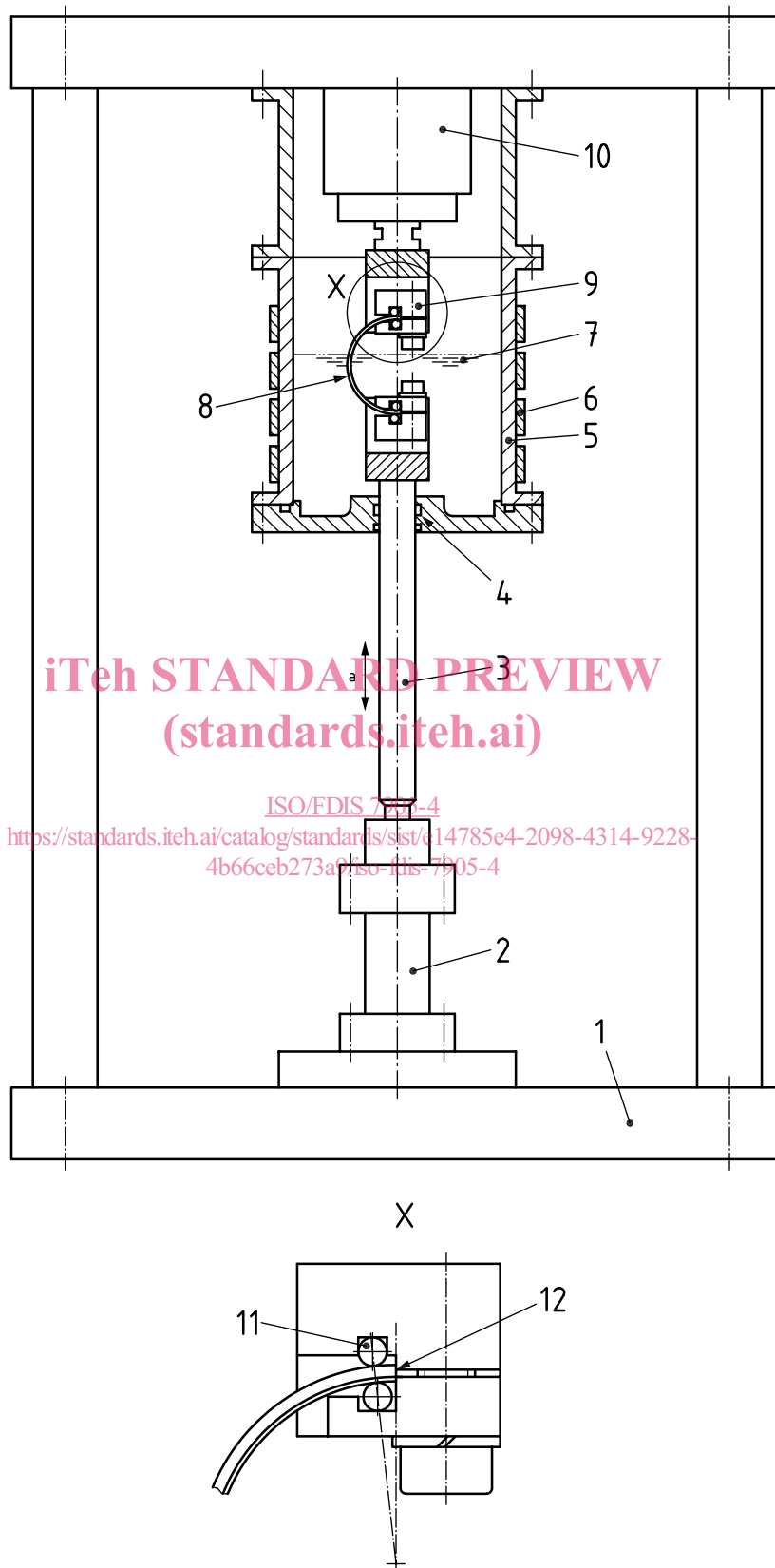
The test specimen shall be half bearings ready for use. Normally, as a result of the loading conditions, the major stresses are located in the crown area of the bearing. Care should be taken before and during the test not to damage the surface mechanically or by corrosion. The advantage of this method is the presence of residual stress associated with the bearing manufacturing process.

## 6 Test methods

The test principle is illustrated in [Figure 1](#). The specimens shall be clamped at one end and loaded at the other end by force or displacement applied radially at the relief parting line runout. The load shall fluctuate from tension to compression within the running surface. Additionally, a tensile or compressive prestress may be applied in order to evaluate dependency upon mean stress. The test equipment is preferably located in a chamber containing a lubricant at fixed levels of temperature with a tolerance of  $\pm 2^\circ\text{C}$ . Alternatively, tests may be conducted in air at fixed levels of temperature with a tolerance of  $\pm 2^\circ\text{C}$ .

Surface stress on the back surface of the bearing at mid-peripheral length is used as nominal stress and may be measured by a strain gauge at this position. The required stress in the lining can be calculated if the steel and lining thicknesses and Young's moduli are known. Alternatively, the radial force at the clamping end  $F$  can be measured by a load cell or calculated from cantilever beam theory and the value of stress in the lining calculated according to [Annex A](#). The values are critically dependent upon the lining and steel thickness which shall be determined by microsection after the tests. The test frequency

shall have a range of 50 Hz to 80 Hz. Crack detection shall be performed by dye penetrant method in accordance with ISO 4386-3 or by microscope.



## Key

- |   |                    |    |                        |
|---|--------------------|----|------------------------|
| 1 | frame              | 8  | half bearing           |
| 2 | hydraulic cylinder | 9  | hinged clamping beam   |
| 3 | connecting shaft   | 10 | load cell              |
| 4 | seal               | 11 | rollers on radial line |
| 5 | sample receptacle  | 12 | fulcrum clamping beam  |
| 6 | strip heater       |    |                        |
| 7 | testing fluid      |    |                        |

$$F = \bar{F} + F_A \cdot \sin(\omega \cdot t) \text{ or } s = \bar{s} + s_A \cdot \sin(\omega \cdot t).$$

where

$F$  radial force at clamping end [N]

$\bar{F}$  mean value of radial force [N]

$F_A$  amplitude of radial force [N]

$\omega$  angular frequency of the radial load [ $s^{-1}$ ]

$t$  time [s]

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Figure 1 — Test principle

The amplitude shall be controlled by force,  $F$ , or displacement,  $s$ .

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## 7 Evaluation and presentation of test results

The endurance limit stresses should be presented in the form of  $\sigma_{el}$ - $N$  curves at predetermined temperature with a tolerance of  $\pm 2$  °C against a detailed description of the bearing material. Normally  $\sigma_{el}$ - $N$  curve testing is terminated for practical considerations at  $50 \cdot 10^6$  stress cycles. The endurance limit stress may be quoted at a specified number of cycles, e.g.  $3 \cdot 10^6$ ,  $10 \cdot 10^6$ ,  $25 \cdot 10^6$  or  $50 \cdot 10^6$ . A specimen without failure during fatigue testing to a specified endurance should be identified in the report. Due to the scatter of test results normally experienced and the statistical nature of the fatigue limit, it is recommended that the results be evaluated based on a statistical method.

Another presentation of the endurance limit stress may be affected by means of the Haigh diagram which plots stress amplitude against mean stress. Metallographic examination will provide detailed evidence of the damage mechanism, corrosive attack and diffusion resulting from thermal effects.

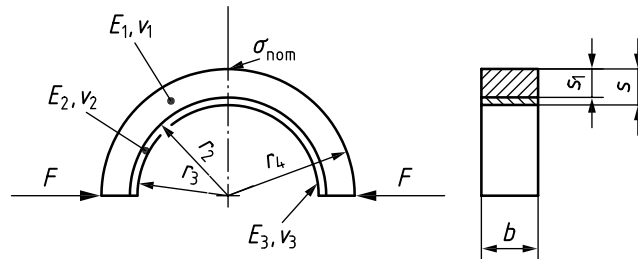


## Annex A (informative)

### Evaluation of stress

#### A.1 Evaluation of stresses

A half-bearing system is described in [Figure A.1](#) by radial dimensions,  $r_4$ , thickness,  $s_1$ , and related to Young's modulus,  $E_{2,0} = 50 \cdot 10^3$  MPa, and to nominal stress,  $\sigma_{\text{nom}}$ .



**Figure A.1 – Half-bearing system**  
(standards.iteh.ai)

The bearing stress calculations are given in [Figure A.2](#) for a two-layer bearing. The data used to construct the charts in [Figure A.2](#) were based on a bearing having a Young's Modulus of  $50 \cdot 10^3$  MPa.

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#### A.2 Worked example

##### A.2.1 General

Given data for a half-bearing:

$$b = 30 \text{ mm}$$

$$E_1 = 210 \cdot 10^3 \text{ MPa}$$

$$E_2 = 69 \cdot 10^3 \text{ MPa}$$

$$E_3 = 22 \cdot 10^3 \text{ MPa}$$

$$F = 100 \text{ N}$$

$$r_2 = 49,10 \text{ mm}$$

$$r_3 = 48,52 \text{ mm}$$

$$r_4 = 51,50 \text{ mm}$$

It is assumed that since the overlay (PbSn11) is relatively thin (0,02 mm), it does not affect the stresses in the other layers. All values in this example are calculated to 3 decimal places.

### A.2.2 To calculate related dimensions

To correct for the actual Young's modulus.

$$E_2^* = E_2 / E_{2,0}$$

$$E_2^* = 69 \cdot 10^3 / 50 \cdot 10^3$$

$$E_2^* = 1,380$$

To calculate the dimensionless steel thickness.

$$s_1^* = (r_4 - r_2) / (r_4 - r_3)$$

$$s_1^* = (51,50 - 49,10) / (51,50 - 48,52)$$

$$s_1^* = 0,805$$

To calculate the dimensionless total thickness.

$$s^* = 2 \cdot [(r_4 - r_3) / (r_4 + r_3)]$$

$$s^* = 2 \cdot [(51,50 - 48,52) / (51,50 + 48,52)]$$

$$s^* = 0,060$$

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To calculate the radius of mean thickness.

$$\bar{r} = (r_3 + r_4) \cdot 0,5$$

$$\bar{r} = (48,52 + 51,50) \cdot 0,5$$

$$\bar{r} = 50,01 \text{ mm}$$

### A.2.3 To calculate nominal stress

$$\sigma_{\text{nom}} = (6 \cdot F \cdot \bar{r}) / (b \cdot s^2)$$

$$\sigma_{\text{nom}} = (6 \cdot 100 \cdot 50,01) / [30 \cdot (51,50 - 48,52)^2]$$

$$\sigma_{\text{nom}} = 112,630 \text{ MPa}$$

### A.2.4 Coefficients $a$ and $b$

Using [Figure A.2](#), and the dimensionless steel thickness,  $s_1^*$ , the coefficients  $a$  and  $b$  can either be calculated or read from the charts.

Running surface:

$$a_{2,0} = 0,014 \quad a_{2,1} = 0,488 \quad a_{2,2} = -0,083$$