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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

Reference number
ISO 7905-4:1995(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 7905-4 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 2, *Materials and lubricants, their properties, characteristics, test methods and testing conditions*.

ISO 7905 consists of the following parts, under the general title *Plain bearings — Bearing fatigue*:

— *Part 1: Plain bearings in test rigs and in applications under conditions of hydrodynamic lubrication*

— *Part 2: Test with a cylindrical specimen of a metallic bearing material*

— *Part 3: Test on plain strips of a metallic multilayer bearing material*

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

Annex A forms an integral part of this part of ISO 7905. Annex B is for information only.

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Plain bearings — Bearing fatigue —

Part 4:
Tests on half-bearings of a metallic multilayer bearing material

1 Scope

This part of ISO 7905 specifies a method for the determination of the endurance limit in fatigue of half-bearings of multilayer bearing materials.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 7905. 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 7905 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 4386-3:1992, *Plain bearings — Metallic multilayer plain bearings — Part 3: Non-destructive penetrant testing.*

ISO 7905-3:1995, *Plain bearings — Bearing fatigue — Part 3: Test on plain strips of a metallic multilayer bearing material.*

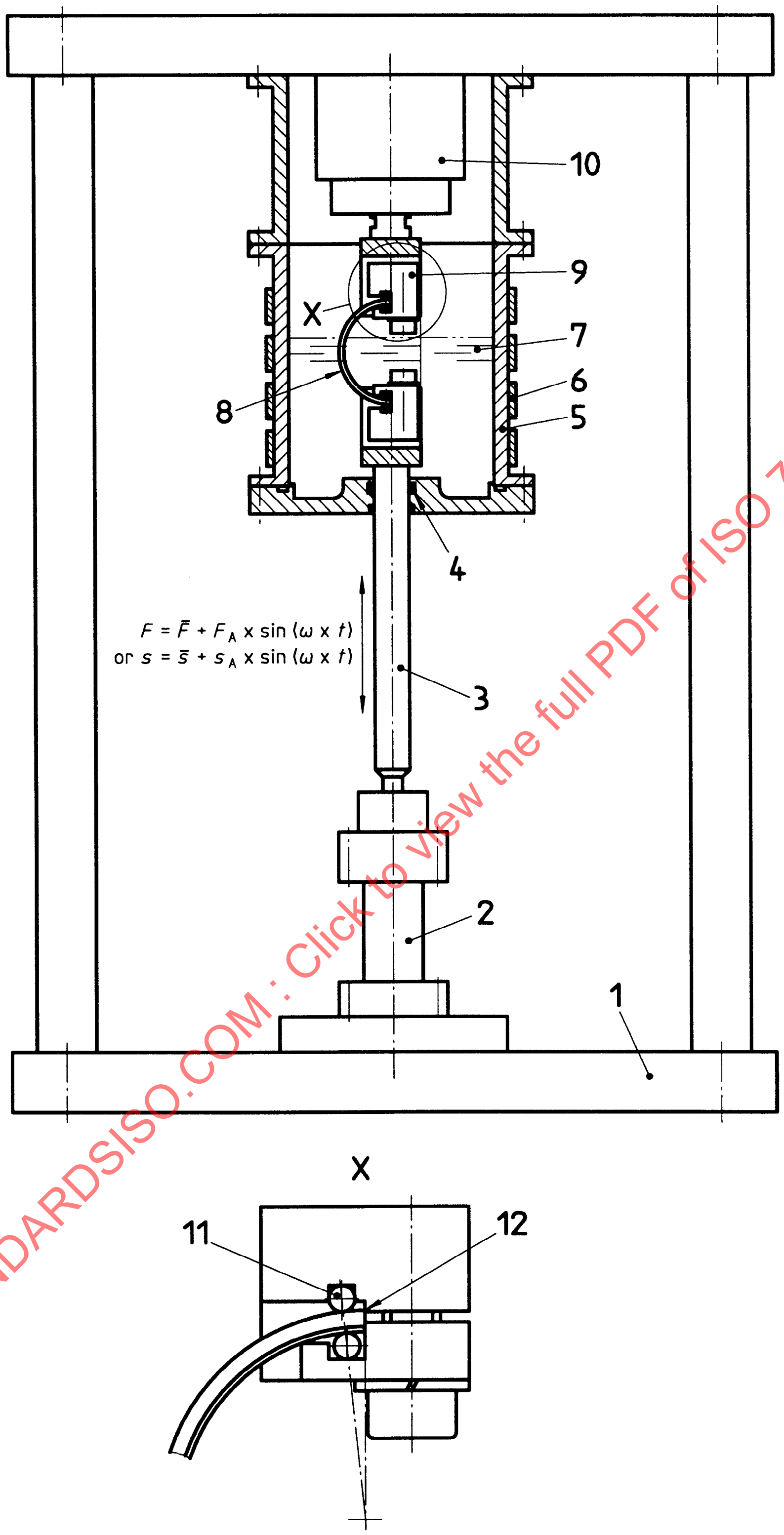
3 Test specimens

The test specimens 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.

4 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 to ± 2 °C. Alternatively tests may be conducted in air at fixed levels of temperature ± 2 °C.

Bending stress may be measured by a strain gauge on the back of the bearing at the crown (mid-peripheral length). The required stress in the lining can be calculated if the steel and lining thicknesses and Young's modulii are known. Alternatively, the radial force at the clamping end F can be measured by 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 (see ISO 4386-3) or by microscope.



1) Frame
2) Hydraulic cylinder
3) Connecting shaft
4) Seal
5) Sample receptacle
6) Strip heater
7) Testing fluid
8) Half bearing
9) Hinged clamping beam
10) Load cell
11) Rollers on radial line
12) Fulcrum clamping beam

Figure 1 — Test principle

The amplitude shall be controlled by force (F) or displacement (s). For detecting crack initiation in thicker layers, the reduction of gauge strain may be used to determine failure onset, see ISO 7905-3.

5 Evaluation and presentation of results

The endurance limit stresses should be presented in the form of σ_{el}-N curves at a predetermined temperature (± 2 °C) against a detailed description of the bearing material. Normally σ_{el}-N curve testing is terminated for practical considerations at 50×10^6 stress cycles. The endurance limit stress may be quoted at a specified number of cycles, e.g. 3×10^6, 10×10^6, 25×10^6 or 50×10^6. 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 on the basis of a statistical method.

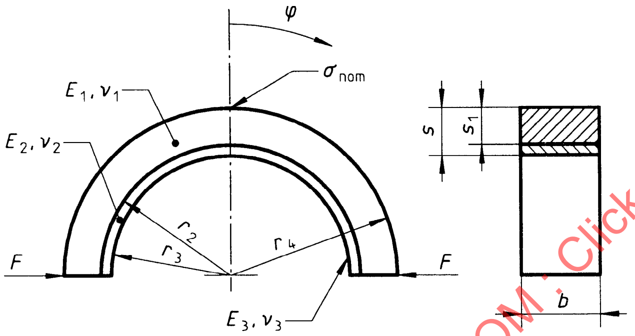
Another presentation of the endurance limit stress may be effected by means of the Haigh diagram which plots stress amplitude against mean stress. Metallographic examination will provide detailed evidence of the damage mechanism, corrosive attack and diffusion resulting from thermal effects.

Annex A
(normative)

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 $E_{2,0} = 50 \times 10^3$ MPa and to nominal stress σ_{nom}.



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

$$\sigma_{nom} = \frac{6 \times F \times \bar{r}}{b \times s^2}$$

$$s^* = 2 \times \frac{r_4 - r_3}{r_4 + r_3}$$

$$s_1^* = \frac{r_4 - r_2}{r_4 - r_3}$$

$$E_2^* = E_2/50 \times 10^3$$

Figure A.1 — Half-bearing system

The solution is given in figure A.2 for a two-layer bearing. It is self-explanatory. An approximation for the stress in the overlay of a three-layer bearing is also given in figure A.2.

A.2 Symbols

Symbol	Definition	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^*	dimensionless Young's modulus, $E^* = E_2/E_{2,0}$	—
E_1	Young's modulus, steel bearing backing, $E_1 = 210 \times 10^3$	MPa
E_2	Young's modulus, lining	Pa
$E_{2,0}$	Young's modulus for figure A.2, $E_{2,0} = 50 \times 10^3$	MPa
E_3	Young's modulus, overlay	Pa
F	radial force	N
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

Symbol	Definition	Unit
s	total thickness of bearing	mm
s^*	dimensionless total thickness, see figure A.1	—
s_1	thickness of steel backing	mm
s_1^*	dimensionless steel backing thickness, see figure A.1	—
t	time	s
σ	stress	Pa
σ^*	dimensionless stress, $\sigma^* = \sigma/\sigma_{nom}$	—
σ_{el}	endurance limit stress	Pa
σ_{nom}	nominal stress	Pa
σ_1	stress at the outside of the bearing back	MPa
σ_1^*	dimensionless stress at the bearing steel back	—
σ_2	stress at the surface of the lining	MPa
σ_2^*	dimensionless stress, lining surface	—
σ_3	stress in overlay	Pa
σ_3^*	dimensionless stress, overlay	—

A.3 Example

Given data for a half-bearing:

$b = 30$ mm

$E_1 = 210 \times 10^3$ MPa

$E_2 = 69 \times 10^3$ MPa

$E_3 = 22 \times 10^3$ MPa

$F = 100$ N

$r_2 = 49{,}10$ mm

$r_3 = 48{,}52$ mm

$r_4 = 51{,}50$ 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.

A.3.1 To calculate related dimensions

See figure A.1.

$s^* = 0{,}06$ $s_1^* = 0{,}8$ $E^* = 1{,}38$

A.3.2 To calculate nominal stress

See figure A.1.

$\sigma_{nom} = 111{,}1$ MPa

A.3.3 To calculate or read the coefficients a and b

See figure A.2.

Running surface:

$a_{2,0} = 0{,}016$ $a_{2,1} = 0{,}495$ $a_{2,2} = -0{,}086$

$b_{2,0} = 0{,}033$ $b_{2,1} = 0{,}339$ $b_{2,2} = -0{,}079$

Bearing back:

$a_{1,0} = 1{,}572$ $a_{1,1} = -0{,}296$ $a_{1,2} = 0{,}049$

$b_{1,0} = -0{,}440$ $b_{1,1} = -0{,}095$ $b_{1,2} = 0{,}034$

A.3.4 To calculate the coefficients A and B

Running surface:

$A_2 = 0{,}535$ $B_2 = 0{,}350$

Bearing back:

$A_1 = 1{,}257$ $B_1 = -0{,}506$

A.3.5 To calculate the dimensionless stress

Running surface: $\sigma_2^* = 0{,}556$

Bearing back: $\sigma_1^* = 1{,}227$

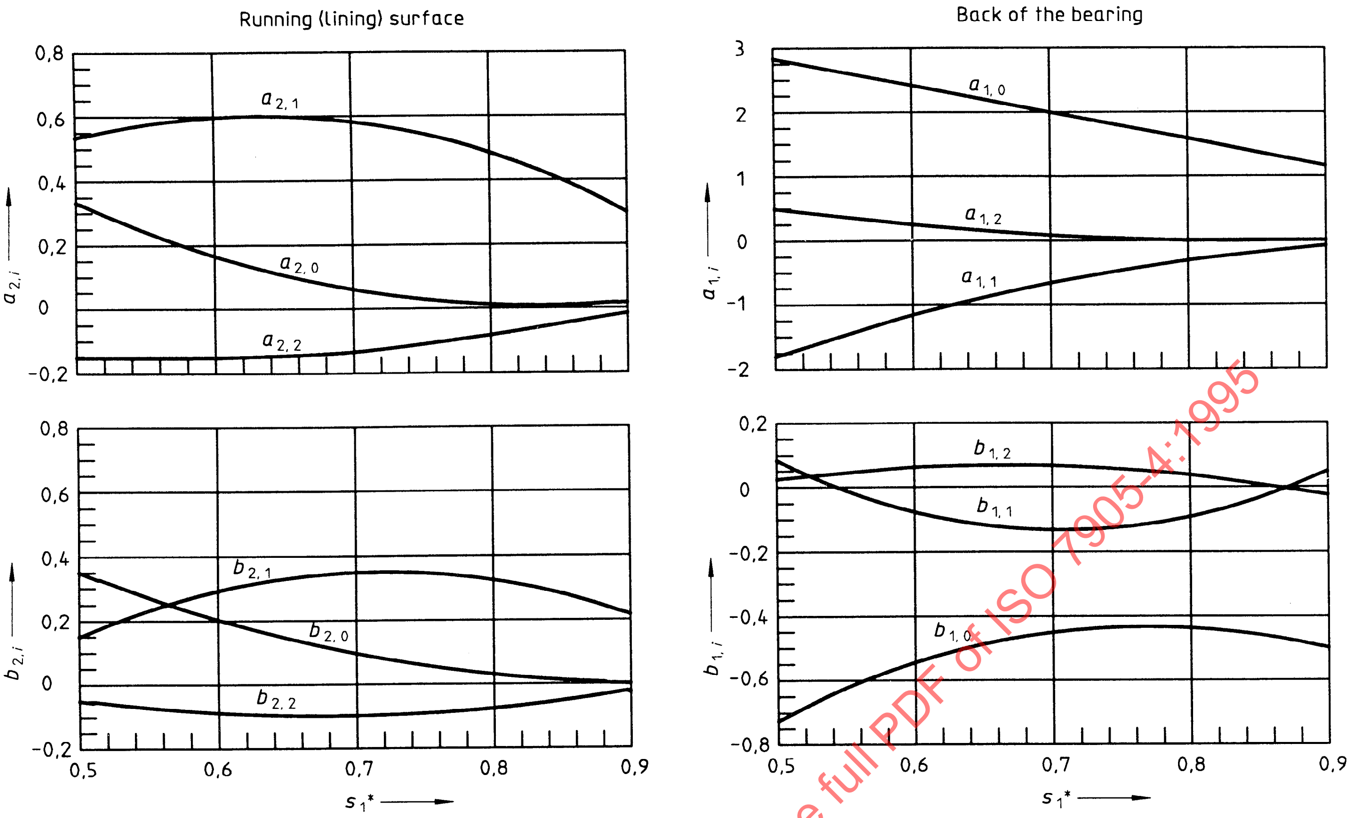
A.3.6 To calculate real stress

Running surface: $\sigma_2 = 61{,}8$ MPa

Bearing back: $\sigma_1 = 136{,}3$ MPa

A.3.7 Approximation for stress in overlay

$\sigma_3 = 19{,}7$ MPa



$a_{2,0} = 1{,}812\,7 - 4{,}181\,2 \times s_1^* + 2{,}418\,6 \times s_1^{*2}$

$a_{2,1} = -0{,}942\,2 + 4{,}921\,6 \times s_1^* - 3{,}906\,9 \times s_1^{*2}$

$a_{2,2} = 0{,}152\,5 - 1{,}154\,4 \times s_1^* + 1{,}070\,3 \times s_1^{*2}$

$b_{2,0} = 1{,}551\,1 - 3{,}282\,1 \times s_1^* + 1{,}730\,9 \times s_1^{*2}$

$b_{2,1} = -1{,}994\,7 + 6{,}592\,0 \times s_1^* - 4{,}593\,3 \times s_1^{*2}$

$b_{2,2} = 0{,}659\,3 - 2{,}255\,0 \times s_1^* + 1{,}664\,7 \times s_1^{*2}$

$A_2 = a_{2,0} + a_{2,1} \times E_2^* + a_{2,2} \times E_2^{*2}$

$B_2 = b_{2,0} + b_{2,1} \times E_2^* + b_{2,2} \times E_2^{*2}$

$\sigma_2^* = A_2 + B_2 \times s^*$

$\sigma_2 = \sigma_2^* \times \sigma_{nom}$

Approximation for stress in overlay: $\sigma_3 = \sigma_2 \times E_3/E_2$

$a_{1,0} = 5{,}386\,6 - 5{,}709\,6 \times s_1^* + 1{,}176\,5 \times s_1^{*2}$

$a_{1,1} = -7{,}101\,5 + 13{,}962\,5 \times s_1^* - 6{,}819\,0 \times s_1^{*2}$

$a_{1,2} = 2{,}674\,5 - 5{,}799\,5 \times s_1^* + 3{,}147\,5 \times s_1^{*2}$

$b_{1,0} = -2{,}673\,9 + 5{,}750\,6 \times s_1^* + 3{,}697\,8 \times s_1^{*2}$

$b_{1,1} = 2{,}209\,6 - 6{,}615\,0 \times s_1^* + 4{,}668\,2 \times s_1^{*2}$

$b_{1,2} = -0{,}590\,0 + 1{,}923\,1 \times s_1^* - 1{,}428\,6 \times s_1^{*2}$

$A_1 = a_{1,0} + a_{1,1} \times E_2^* + a_{1,2} \times E_2^{*2}$

$B_1 = b_{1,0} + b_{1,1} \times E_2^* + b_{1,2} \times E_2^{*2}$

$\sigma_1^* = A_1 + B_1 \times s^*$

$\sigma_1 = \sigma_1^* \times \sigma_{nom}$

Figure A.2 — Stress evaluation in two- and three-layer bearings

Annex B
(informative)

Bibliography

[1] ISO 3548:1978, *Plain bearings — Thin-walled half bearings — Dimensions, tolerances and methods of checking.*

[2] ISO 4378-1:1983, *Plain bearings — Terms, definitions and classification — Part 1: Design, bearing materials and their properties.*