International Standard **ISO** 7148/1

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Plain bearings — Testing of the tribological behaviour of bearing materials — Part 1 : Testing of the friction and wear behaviour of bearing material/mating material/oil combinations under conditions of boundary lubrication

Paliers lisses — Essai du comportement tribologique des matériaux antifriction — Partie 1 : Essai du comportement au frottement et à l'usure des ensembles matériau antifriction/matériau conjugué/huile dans les conditions de lubrification limite

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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Plain bearings — Testing of the tribological behaviour of bearing materials — Part 1 : Testing of the friction and wear behaviour of bearing material/mating material/oil combinations under conditions of boundary lubrication

0 Introduction

This International Standard specifies the determination of the tribological behaviour of bearing materials to be used for application in oil (see note in clause 4) lubricated bearings.

The surfaces of the journal and the bearing in an oil lubricated bearing, designed to run under conditions of hydrodynamic lubrication, are not always fully kept apart by a thick oil film. The percentage of the total lifetime of the bearing, during which this is the case, varies considerably from one application to the other. If thick film lubrication is not provided, mixed or boundary lubrication prevails. Under such conditions, wear of the bearing and mating material cannot be avoided.

1 Scope and field of application

This part of ISO 7148 specifies a test procedure to measure the friction and wear of materials for oil lubricated bearings under conditions of boundary lubrication with ample supply of lubricant to the friction couple.

The test procedure enables the friction and wear behaviour of bearing material/mating material/oil combinations to be compared with that of other combinations, thus facilitating the selection of a bearing material for a bearing running repeatedly or for long periods under conditions of boundary lubrication, low speed and continuous rotation. Owing to differences in test conditions, absolute friction and wear values can be expected to vary from one test facility to another.

2 References

ISO 468, *Surface roughness — Parameters, their values and general rules for specifying requirements.*

ISO 4385, *Plain bearings — Compression testing of metallic bearing materials.*

3 List of symbols

b index referring to the condition of boundary lubrication

f coefficient of friction

F_n normal force, in newtons

F_f friction force, in newtons

k wear coefficient, in cubic millimetres per newton metre

s sliding distance, in metres

t_{oil} temperature of the oil bath, in degrees Celsius

u sliding velocity, in metres per second

w_l material removed by wear as measured by a change in length, in micrometres

w_v material removed by wear as measured by a change in volume, in cubic millimetres

$w_{l/s}$ linear wear rate, in micrometres per kilometre

$w_{v/s}$ volumetric wear rate, in cubic millimetres per metre

ϱ overlap ratio (area of contact divided by area of wear track)

4 Definitions

NOTE — For the purposes of this part of 7148, the term "oil" shall be understood in its widest possible meaning, i.e. encompassing mineral and synthetic oils.

4.1 boundary lubrication : Type of lubrication in which friction and wear between two surfaces in relative motion are determined by the properties of the surface and by the properties of the lubricant other than bulk viscosity.

4.2 coefficient of friction : Ratio of the friction force between two bodies to the normal force pressing these bodies together, i.e. :

$$f = \frac{F_f}{F_n}$$

4.3 wear rate : The quantity of material removed in unit distance of sliding as a result of wear, i.e. :

$$w_{v/s} = \frac{w_v}{s} \quad \text{or} \quad w_{l/s} = \frac{w_l}{s}$$

4.4 wear coefficient : The volumetric wear rate referred to the applied normal force, i.e. :

$$k = \frac{w_{v/s}}{F_n}$$

5 Equipment

Figures 1 and 2 show schematic drawings of two possible specimen assemblies. A stationary specimen (the pin) made of the bearing material to be tested is pressed with a known normal force against a rotating specimen (the disc) made from material of the mating component (i.e. usually low carbon steel). The area of contact between the pin A and disc B shall, preferably, be completely immersed in the oil. Spray lubrication may be used, if the volume of the lubricant supply is sufficient to ensure that the wear rate is not dependent upon the lubricant flow-rate. Test oil should not be recirculated or re-used.

In practice, surfaces with cylindrical surface curvature (journal bearings) will frequently be offered for testing. If they are multilayer materials, two procedures are open :

a) adapt the radius of the disc to that of the pin (see figure 1);

b) start testing with a line contact situation (radius of the pin larger than the radius of the disc).

If multilayer materials with flat surfaces (thrust bearings) are to be tested, the pin-on-disc arrangement with a curved contact area (see figure 1) will only do if an initial line contact is accepted. Otherwise the pin-on-disc arrangement with a flat contact area (see figure 2) shall be used.

The oil temperature, t_{oil}, shall be kept constant at the desired test value with an accuracy of ± 0,5 K. If tests are to be performed under a cover gas, use shall be made of a sufficiently airtight friction chamber. Facilities shall be available for continuous friction and wear measurement. A low vibration level is required to give reproducible results.

6 Preparation of test surfaces

After giving the test surfaces a suitable surface finish (see clause 8), the specimens shall be thoroughly cleaned of contamination, for instance in a vapour-degreasing apparatus.

7 Test procedure

Apply a normal force, F_n, (see clause 8) and a sliding velocity, u, equal to 0,01 ± 0,001 m/s. At such value of u, boundary lubrication conditions are expected to prevail.

Friction sliding distance and wear sliding distance curves should be recorded so that the periods of running in and of steady state can be distinguished. The total sliding distance should be given with the results. After the test has been completed, measure the wear of the disc surface, for instance by profile tracing with a stylus instrument so that the contribution of the wear of the disc to the total wear can be evaluated. This will also reveal whether the disc surface has been scratched by contact with the pin. In addition, wear of the pin should be determined by weighing before and after the test. The wear of the pin should be not less than 5 mg.

After the test has been completed, inspect the surface conditions of the pin and of the disc (formation of a reaction layer, transferred material, grooves, etc.).

The materials used for the pin and the disc, and the oil should be renewed for each test.

8 Independent test variables

In comparative testing of different material/oil combinations, the methods of machining and finishing the pin (bearing material) and the disc (mating material) and the values of the following independent test variables shall be chosen and kept constant during the test programme :

a) initial roughness, R_a and R_z, of the pin and of the disc (see ISO 468);

b) normal force, F_n;

c) oil temperature, t_{oil};

d) sliding distance, s;

e) overlap ratio, ϱ.

NOTE — In order to simulate friction and wear in a given bearing, realistic values of the roughness, R_a and R_z, the normal force, F_n, the oil temperature, t_{oil}, and a sufficiently long sliding distance, s, shall be chosen.

In practice, a journal surface will have a workshop surface roughness which is dependent upon the technical possibilities in the workshop, the type of machining process and the care and professional skill that is devoted to the production of the journal. Thus when materials are being evaluated for a specific application, it is important that the surface shall be typical of that which will be used in the application.

At prolonged running under conditions of boundary lubrication, the roughness of the steel disc may (but does not necessarily) change gradually as a result of contact with the bearing material [1]. This, in turn, may lead to change in the wear rate of the bearing material. In selecting materials for applications in which the bearing is designed to run under conditions of boundary lubrication for appreciable periods of time, this effect can be taken into account by performing long-term tests, measuring the wear volume as a function of the sliding distance. After the test has been completed, the roughness of the disc surface, R_a and R_z, shall be measured and given with the test results.

As far as F_n is concerned, the most widely acceptable compromise is to make the maximum force per unit projected pin area equal to the force per unit projected bearing area. It may be desirable to apply stepwise loading.

For t_{oil}, a temperature corresponding to the highest temperature that is expected to occur in practice should be chosen.

If the friction and wear behaviour of a bearing material/mating material/oil combination is to be compared with other combinations without a specific application in mind, the roughness values, R_a and R_z, the normal force, F_n, and the oil temperature, t_{oil}, should, preferably, be varied between wide limits.

9 Description of materials, oil, test conditions and results

Unless agreed otherwise, for description of materials, oil, test conditions and test results, the following data shall be supplied.

9.1 Materials

9.1.1 Bearing material

Type

Chemical composition (m/m)

Method of production

Heat treatment

Surface treatment

Micro structure

Hardness

0,2 % proof stress $R_{p0,2}$ (see ISO 4385)

9.1.2 Material of mating component

Type

Chemical composition (m/m)

Heat treatment

Surface treatment

Micro structure

Hardness

9.1.3 Lubricant

Type (including information on viscosity and, if possible, on additives).

NOTE — In certain cases it may be preferable to use oil from the actual application for which the materials are being evaluated.

9.2 Cover gas

Type

Relative humidity, expressed as a percentage

9.3 Specimens

9.3.1 Pin

Material : bearing material (see 9.1.1)

Dimensions

Surface finishing method

R_a and R_z, in micrometres

9.3.2 Disc

Material : mating material (see 9.1.2)

Dimensions

Overlap ratio, ϱ

Surface finishing method

R_a and R_z, in micrometres

9.4 Operating variables

Normal force, F_n, in newtons

Sliding velocity, u, in metres per second

Lubricant temperature, t_{oil}, in degrees Celsius

Sliding distance, s, in metres

NOTE — The sliding velocity, u, is fixed at 0,01 ± 0,001 m/s.

9.5 Test results

Designation	Pin	Disc	Symbol	Units
Friction coefficient in the period of steady state			f_b	
Linear wear rate of the pin in the period of steady state			$w_{l/s}$	µm/km
Volumetric wear rate of the pin in the period of steady state[1]			$w_{v/s}$	mm^3/m
Wear coefficient of the pin in the period of steady state[1]			k_b	$mm^3/(N\cdot m)$
Total wear volume of the pin			w_{vp}	mm^3
a) calculated from the wear-sliding distance curve				
b) calculated from the loss of mass				
Total wear volume of the disc			w_{vd}	mm^3
Surface condition	Pin	Disc		
Roughness				
R_a				µm
R_z				µm
Transferred material	( )	( )		–
Reaction layer	( )	( )		–
Scratches				
– none	( )	( )		–
– a few (1 to 3)	( )	( )		–
– many	( )	( )		–

1) For multilayer materials, the lining thickness shall be thick enough to enable a steady-state condition to be achieved or the specimen shall be shaped to match the radius of the disc.