INTERNATIONAL STANDARD

ISO 7148-2

Second edition
2012-10-01

Plain bearings — Testing of the tribological behaviour of bearing materials —

Part 2: Testing of polymer-based bearing materials

Paliers lisses — Essai du comportement tribologique des matériaux antifriction —

Partie 2: Essai des matériaux pour paliers à base de polymère

Reference number
ISO 7148-2:2012(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 7148-2 was prepared by Technical Committee ISO/TC 123, *Plain bearings*, Subcommittee SC 2, *Materials and lubricants, their properties, characteristics, test methods and testing conditions*.

This second edition cancels and replaces the first edition (ISO 7148-2:1999), which has been technically revised.

ISO 7148 consists of the following parts, under the general title *Plain bearings — Testing of the tribological behaviour of bearing materials*:

— *Part 1: Testing of bearing metals*

— *Part 2: Testing of polymer-based bearing materials*

Plain bearings — Testing of the tribological behaviour of bearing materials —

Part 2:
Testing of polymer-based bearing materials

1 Scope

This part of ISO 7148 specifies tribological tests of polymer-based plain bearing materials under specified working conditions, i.e. load, sliding velocity and temperature, with and without lubrication. From the test results, data are obtained which indicate the relative tribological behaviour of metal-polymer and polymer-polymer rubbing parts.

The purpose of this part of ISO 7148 is to obtain, for polymer material combinations used in plain bearings, reproducible measured values for friction and wear under specified and exactly-defined test conditions without lubrication (dry surfaces) and with lubrication (boundary lubrication).

The test results give useful information for practical application only if all parameters of influence are identical. The more the test conditions deviate from the actual application, the greater the uncertainty of the applicability of the results.

2 Normative references

The following referenced documents are indispensable for the application 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 527-2, *Plastics — Determination of tensile properties — Part 2: Test conditions for moulding and extrusion plastics*

ISO 527-3, *Plastics — Determination of tensile properties — Part 3: Test conditions for films and sheets*

ISO 2818, *Plastics — Preparation of test specimens by machining*

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

ISO 6691, *Thermoplastic polymers for plain bearings — Classification and designation*

3 Symbols, units and abbreviated terms

See Table 1.

Table 1 — Symbols, units and abbreviated terms

Symbol	Term	Unit
A, B, C, D, E	Test method	-
a	Sliding distance	km
dr	Dry	-
f	Coefficient of friction; ratio between friction force and normal force, i.e.: $f = \frac{F_f}{F_n}$	-
F_f	Friction force	N
F_n	Normal force	N
gr	Grease	
K_w	Coefficient of wear, volumetric wear rate related to the normal force, i.e.: $K_w = \frac{V_w}{F_n \times a} = \frac{w_v}{F_n}$	mm³/(N·km)
l_w	Linear wear as measured by change in distance	mm
M_f	Friction moment	Nm
oi	Oil	-
$\bar{p}$	Specific force per unit area (force/projected contact area)	N/mm²
$R_{d,B}$	Compression strength	N/mm²
$R_{d0,2}$	Compression limit 0,2 %	N/mm²
so	Solid lubricant	
T	Specimen's temperature near the sliding surface during testing under steady-state conditions	°C
T_{amb}	Ambient temperature	°C
T_g	Glass transition temperature	°C
T_{lim}	Maximum permissible temperature	°C
t_{Ch}	Test duration	h
U	Sliding velocity	m/s
V_W	Material removed by wear as measured by change in volume	mm³
w_l	Linear wear rate, i.e.; $w_l = \frac{l_w}{a}$	mm/km
w_v	Volumetric wear rate, i.e.: $w_v = \frac{V_w}{a}$	mm³/km
η	Lubricant viscosity	mPa·s

4 Special features for the tribological testing of polymer-based materials

Polymers have a low thermal conductivity and a low melting temperature, so that heat resulting from contact friction may lead to partial melting and hence feign wear. Due to the high thermal expansion of polymers (up to 10 times higher than that of steel) results obtained can be misleading because the test specimens have expanded under frictional heat. Hence allowance shall be made for the effects of thermal expansion (change of clearance) and thermal conductivity (melting) when assessing the results. Where possible the temperature of both test specimens should be controlled.

Polymers have a glass transition temperature, T_g, which depends on their chemical structure. At this temperature, their physical properties and their tribological behaviour may change.

Injection-moulded polymer surfaces have different properties from machined surfaces. The test specimens shall be tested with the same surface conditions as they have in practical application.

Reinforcements and fillers, i.e. fibres, may lead to very strong anisotropy of the material and influence its wear behaviour depending on fibre orientation. The test specimens should have the same fibre orientation as in practical application.

In order to avoid stick-slip, the test rig shall be very stiff and shall not be susceptible to vibrations.

The tribological behaviour of polymers depends very strongly on the material combination, which part moves and which part remains stationary. The test system shall be similar to practical application.

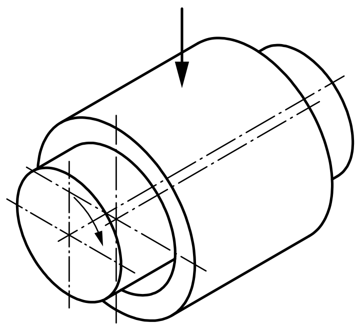
Polymers show wear processes that are different from that of metals. There are not only abrasive processes with powder-like wear debris, but also adhesive processes with the creation of transfer layers which may be smooth or rough. Also ploughing wear and melting or plastic deformation is possible. Therefore, wear cannot be gravimetrically measured in all cases and the wear status shall be judged after the tests (whether the surfaces are fine- or coarse- grained, scored or plucked out, scaled, melted or plastically deformed).

Some polymers may show poor repeatability of the results and require repeated testing (i.e. six or more repetitions).

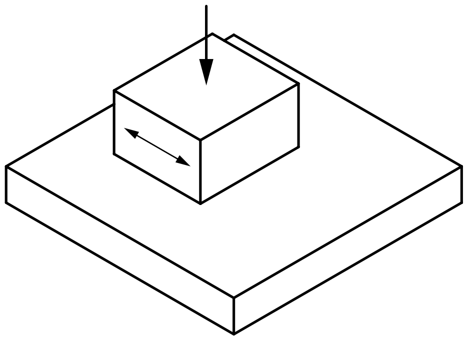
The preparation and preparatory treatment (e.g. conditioning, storage, cleaning) of the test specimens can have a high influence on performance.

In some thermoplastics, e.g. polyamides, moisture absorption effects a gradual change in linear dimensions and modifies their mechanical properties. Environmental parameters should, therefore, be controlled in the test array. Moisture absorption prohibits gravimetrical measurement of wear.

The more the test conditions deviate from the actual application, the greater is the uncertainty of the applicability of the results (see Figures 1 and 2).

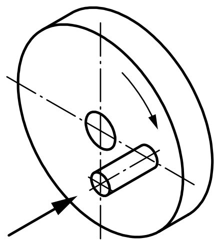


a) Plain bearing-on-shaft

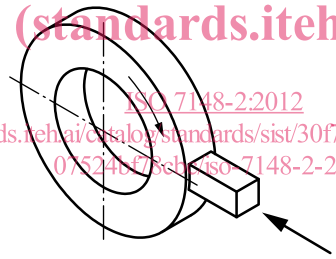


b) Linear guidance system

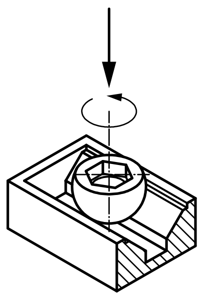
Figure 1 — Simulation of real rubbing contacts



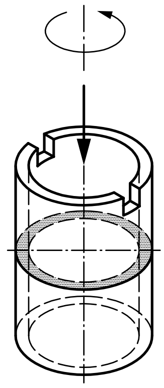
a) Pin-on-disc



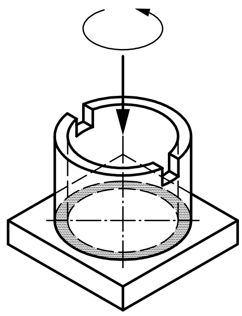
b) Block-on-ring



c) Sphere-on-prism



d) Rotation under thrust load — Sleeve-to-sleeve



e) Rotation under thrust load — Sleeve-to-plate

Figure 2 — Simulation under approximated practical testing conditions and model systems

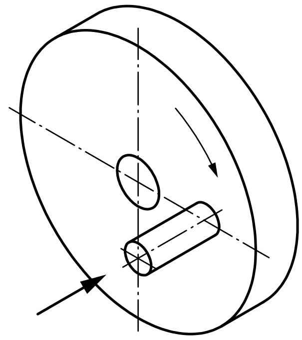
5 Test methods

5.1 General

Different test methods are provided for tests in accordance with this part of ISO 7148 so that the following contact geometries are available. The test methods should correspond to the practical application as closely as possible.

5.2 Test method A — Pin-on-disc

See Figure 3.



Advantages:

— basic testing of simple test specimens;
— testing of tribological properties;
— no increase of sliding surface area due to wear;
— initial ranking of materials;
— simulation of linear guidance system [see Figure 1b)].

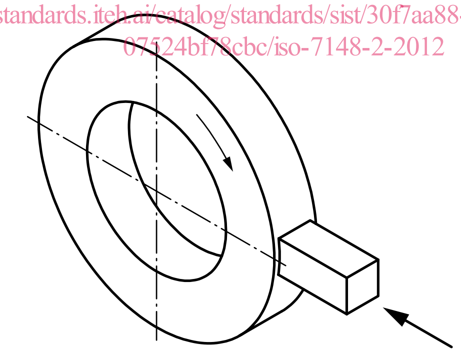
Disadvantages:

— edge of the pin might wipe off lubricant;
— no injection moulding of the pin with fibre reinforced material;
— no injection moulding of the disc because of problems with shrinkage.

Figure 3 — Test method A — Pin-on-disc

5.3 Test method B — Block (or pin)-on-ring

See Figure 4.



Advantages:

— basic testing of simple test specimens;
— testing of tribological properties;
— no increase of sliding surface area due to wear;
— initial ranking of materials;
— with and without lubrication.

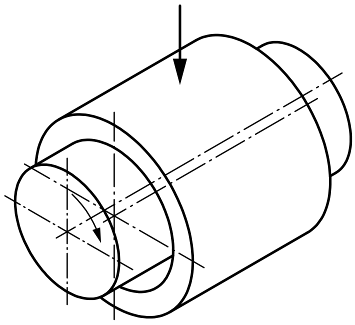
Disadvantages:

— no injection moulding of the block because of problems with shrinkage and fibre orientation;
— edge of the block might wipe off lubricant;
— no injection moulding of the disc because of problems with shrinkage.

Figure 4 — Test method B — Block (or pin)-on-ring

5.4 Test method C — Plain bearing-on-shaft

See Figure 5.



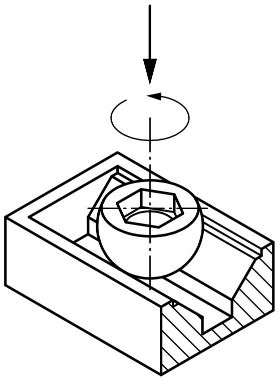
Advantages:
- — best simulation of all possible systems;
- — testing of original or scaled bearings;
- — prediction of practical behaviour;
- — with and without lubrication.

Disadvantages:
- — long testing time (accelerated testing might cause excessive frictional heating);
- — difficult alignment of the test bearing;
- — increasing sliding surface area due to wear under boundary lubrication.

Figure 5 — Test method C — Plain bearing-on-shaft

5.5 Test method D — Sphere-on-prism

See Figure 6.



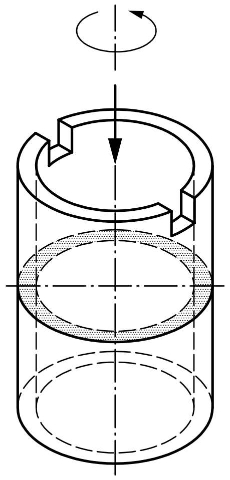
Advantages:
- — testing of polymer/polymer or polymer/metal combinations;
- — with and without lubrication (test specimen contains reservoir for lubricant);
- — testing of lubricant's interaction with polymers;
- — injection-moulded test specimens available;
- — self-adjustment of the alignment of the sliding couple;
- — increasing sliding surface area due to wear under boundary lubrication.

Disadvantages:
- — plastic deformation might affect results;
- — increasing sliding surface area due to wear under dry conditions.

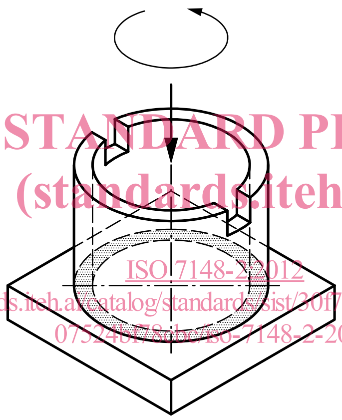
Figure 6 — Test method D — Sphere-on-prism

5.6 Test method E — Rotation under thrust load

See Figure 7.



a) E1 — Sleeve-to-sleeve



b) E2 — Sleeve-to-plate

Figure 7 — Rotation under thrust load

Advantages:

— basic testing of simple specimens;

— injection-moulded test specimens available;

— testing of tribological properties;

— initial ranking of material;

— no increase of sliding surface area due to wear;

— continuous sliding between specimens;

— with and without lubrication.

Disadvantages:

— plastic deformation affects results;

— shrinkage at sliding surface on injection-moulded specimens affects results.