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Plain bearings — Evaluation of the tribological properties of polymer-based materials

*Paliers lisses — Évaluation des propriétés tribologiques des matériaux à base
de polymères*



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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 main task of ISO technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a technical report of one of the following types:

- type 1, when the necessary support within the technical committee cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when the subject is still under technical development requiring wider exposure;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical reports are accepted for publication directly by ISO Council. Technical reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical reports type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 8285, which is a technical report of type 2, was prepared by Technical Committee ISO/TC 123, *Plain bearings*.

Annexes A and B of this Technical Report are for information only.

Two versions of this Technical Report have been prepared since 1983. Most of the comments from the member bodies have been incorporated in this version.

It covers the subject dealt with in ISO/TR 7147 : 1985, *Plain bearings — Testing of the tribological behaviour of plastics*. There was a strong feeling among ISO/TC 123 members (Austria, Germany, F.R., United Kingdom) that both documents should be published as International Standards because of their importance.

It was therefore decided to publish DP 8285 as a Technical Report in order to collect any further comments. At the same time, a new version is being prepared by the USSR member body that combines both Technical Reports. A new round of tests will be conducted and, if approved, an International Standard will be prepared.

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Plain bearings — Evaluation of the tribological properties of polymer-based materials

1 Scope

This Technical Report deals with the tribological testing of bulk plastic specimens under specified working conditions, i.e. load, sliding velocity and temperature, without lubrication. From the test results, data are obtained about the tribological behaviour of steel-plastic rubbing pairs which can be used in practice for predicting the working capacity of a friction unit.

It specifies the test conditions, equipment and programmes that allow reproducibility of the results at particular conditions of the specimen preparation and testing.

This Technical Report specifies the specimen shape, conditions of the rubbed surfaces of the plastic and steel, tolerable run-out of the rotating counterface, heat transfer between the device housing and counterface, the range of variations in the friction process parameters in order to reach the reproducibility of the results in the tribological testing of plastics. It proposes technical solutions for the standard equipment used for the tribological testing of plastics.

2 Symbols and units

See table 1.

Table 1

Symbol	Parameter	SI unit
f	Coefficient of friction	—
F_n	Normal force	N
F_f	Friction force	N
p	Normal specific load	N/mm ²
σ_s	Compression strength of polymer	N/mm ²
Q	Thermal constant of a friction unit	°C·m·s/N
T	Temperature in the friction zone	°C
ΔT	Difference between the temperature in the contact zone and the ambient temperature	°C
u	Sliding velocity	m/s
t	Testing period	h
s	Sliding distance	km
w_l	Linear wear	µm
w_t	Wear rate	µm/h
w_s	Wear intensity	µm/km
k	Wear factor	mm ² /N
T_m, T_s	Melting and softening temperatures of polymer, respectively	°C

3 Definitions

3.1 coefficient of friction, f : Ratio of the friction force resulting from the sliding of a plastic against a steel to the normal force pressing the two bodies together:

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

3.2 wear rate, w_t : Ratio of the linear wear of the tested plastic block to the testing period:

$$w_t = \frac{w_l}{t}$$

3.3 wear intensity, w_s : Ratio of the linear wear to the sliding distance:

$$w_s = \frac{w_l}{s}$$

3.4 wear factor, k : Ratio of the wear intensity to the normal specific load:

$$k = \frac{w_s}{p}$$

4 Shape and manufacture of test specimens

To estimate the tribological properties of plastics in accordance with this Technical Report, a tribosystem should consist of a steel roller and a plastic block with mateable friction surfaces (see figure 1). The possible material combinations for the block and the roller are given in table 2.

Table 2

No.	Combination	
	Block	Roller
I	Plastic	Metal
II	Metal	Plastic
III	Plastic	Plastic

The basic mating combination complying with this Technical Report is combination I.

4.1 Plastic block

The block can be made by moulding, injection moulding, turning or by milling, making use of the near surface structure effects formed by moulding or machining (see figures 2 and 3).

The block is 10 mm high, 10 mm wide and 20 mm long (see figure 2).

The roughness of the plastic block depends on the machining conditions; in case of moulding or injection moulding, it depends on the roughness of the moulding parts ($R_a = 0,3 \mu\text{m}$ to $0,6 \mu\text{m}$).

4.2 Test roller

A test roller complying with this Technical Report is a combination of a steel bushing and a heat-insulating bushing. The heat-insulating bushing is made of textolite and is pressed into the steel bushing. The dimensions of the mating parts are shown in figure 4.

The steel bushing is made of steel with a carbon content of between 0,45 % and 0,8 %, of hardness 45 HRC to 50 HRC, for example steel complying with ISO 683 (all published parts).

The thermally insulated roller is designed for comparative tests; it provides reproducibility of the results when testing equipment of different designs is employed.

For certificate testing, the temperature control of the test roller is important. A schematic representation of the thermal regulation is shown in figure 5.

The surface roughness, R_a , of the roller may have the following values, depending on the machining or preparation of the roller friction surfaces:

- a) $R_a = 0,63 \mu\text{m}$ to $0,8 \mu\text{m}$;
- b) $R_a = 0,25 \mu\text{m}$ to $0,32 \mu\text{m}$;
- c) $R_a = 0,04 \mu\text{m}$ to $0,05 \mu\text{m}$.

Alternative b) is preferred when estimating the tribological properties of plastics.

5 Preparation of test specimens

The specimens (block and roller) should be cleaned before the tests to remove various contaminants with liquids that do not dissolve the specimen material.

5.1 Polymeric block

The block surface should be cleaned with a liquid at a temperature of $23 \text{ }^\circ\text{C} \pm 5 \text{ }^\circ\text{C}$, at a relative humidity of 50 %. The blocks should be dried in air and then placed in a vacuum at 10^{-3} torr for 2 h.

Liquids easily volatile at $23 \text{ }^\circ\text{C} \pm 5 \text{ }^\circ\text{C}$ that do not dissolve plastics or their components, for example petrol, acetone,

ethanol or cyclohexane, shall be used for cleaning. Cleaning should be carried out in a bath of one of the above liquids.

The recommendations of the plastics manufacturer should be taken into account when choosing a liquid for cleaning.

5.2 Test roller

One of the liquids given in 5.1 should be used for cleaning the roller surface. The roller should be dried in an oven at $50 \text{ }^\circ\text{C}$ to $60 \text{ }^\circ\text{C}$ without ventilation.

6 Test equipment

Testing according to this Technical Report may be carried out with block-roller devices presently available. They need to be modernized and some technological limitations have to be observed to ensure the reproducibility of the results.

The technological limitations are as follows.

6.1 The comparative tests should be carried out with a heat-insulating bushing between the test shaft and roller (see figures 4 and 6). The heat dissipation will improve the reproducibility of the test results obtained with equipment of different designs.

6.2 The certification tests shall be carried out with thermally regulated rollers (see figure 5) or a multistep device with a thermally regulated shaft (see figure 7). The thermostatic regulation is done to estimate the tribological properties of plastics at a constant counterface bulk temperature.

6.3 The radial run-out of the roller working surface should not be greater than $25 \mu\text{m}$.

The test rig should allow

- a) the smooth control and maintenance of the sliding velocity at a given level within 2,5 % of the existing value;
- b) continuous loading of the specimen (block) within 2,5 % of the existing value;
- c) measurement of the friction coefficient, temperature of the roller sliding surface, and the linear wear of the block.

The continuous control of the linear wear is realized with a special instrument with an accuracy of $\pm 0,5 \mu\text{m}$ [the use of such an instrument cuts the testing period of the specimens after running-in (see figure 6)].

To measure average temperatures of the plastic and metal friction surfaces, a thermocouple is located within a through-hole in the plastic block 0,2 mm above the friction surface.

At the stage of thermostatic regulation, the required bulk temperature of the roller and the shaft in a multistep machine is controlled by variations in the operating conditions of the liquid thermostat.