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Plastics — Friction and wear by sliding — Identification of test parameters

Plastiques — Frottement et usure par glissement — Identification des paramètres d'essai

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Tel. + 41 22 749 01 11
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Contents

Page

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.

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

International Standard ISO 6601 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical properties*.

This second edition cancels and replaces the first edition (ISO 6601:1987), which has been technically revised.

Introduction

The resistance to movement of two surfaces against each other (sliding friction) consumes energy, causes wear and generates heat. In some applications, friction is a nuisance; others require a given level of friction (for example: brakes, shoe soles, etc.). It is important to be able to characterize the friction with certain parameters which are identified in this International Standard.

Plastics — Friction and wear by sliding — Identification of test parameters

1 Scope

This International Standard identifies the parameters associated with the friction and wear of plastics and the conditions that test methods should address to determine these characteristics.

It is intended to provide a basis for further International Standards dealing with methods of test and the specifications of materials.

2 General

The sliding friction behaviour of one material against another can be defined by such terms as the coefficient of friction, rate of wear, resistance to seizure or the "pv-limit" factor[1).]

These terms are dependent on various parameters which may be classified into three groups:

a) intrinsic parameters relating to the materials involved, such as their nature, physico-chemical state, surface condition and finish;

b) external parameters relating to the sliding conditions, such as applied load, sliding velocity, characteristics of the motion, mode of contact (see Figure 1), ambient conditions (temperature, humidity) and interstitial matter (lubricant, wear debris);

c) parameters depending on both the nature of the materials involved and the sliding conditions, particularly the surface temperature of the rubbing surfaces.

3 Analysis of friction and wear tests

3.1 General

Friction and wear processes can be described by systematic analysis of the parameters given in 3.2 to 3.5.

3.2 Technical function of tribological systems

For example: transmission of motion, restriction of motion, transmission of force.

1) The pv-limit factor is the product of the bearing pressure p based upon projected area and the surface velocity v and is usually presented graphically as p vs. v on log-log paper.

3.3 Variables involved in the friction and wear process

a) type of motion (sliding, rolling, impact, flow or any combination thereof);

b) variation with time (continuous, oscillatory, intermittent);

c) normal load, F_n;

d) surface velocity, v;

e) temperature, T;

f) test duration, t.

3.4 Structure of tribological systems

3.4.1 Elements

a) body;

b) counter-body;

c) interfacial medium;

d) surrounding medium.

3.4.2 Properties of the elements

a) bulk properties (chemical composition, physical characteristics, mechanical properties, hardness);

b) surface properties (roughness and physico-chemical characteristics).

3.4.3 Interactions between the elements

a) mode of contact (see Figure 1);

b) type of friction (dry friction, boundary lubrication, mixed lubrication, hydrodynamic lubrication, gas lubrication);

c) wear mechanisms, which are often classified into

   1) adhesive wear by tearing of adhered parts from sliding surfaces,

   2) abrasive wear (abrasion) by hard particles present on sliding surfaces,

   3) degradative wear by a hostile environment,

   4) surface fatigue wear by a process of rolling over a track, and

   5) surface wearing asperities creating ploughed surface protuberances (material deposited alongside the furrow).

The modes of contact shown in Figure 1 may also be classified as follows:

a) conformal: radii of curvature of the two solids in the same direction;

   EXAMPLE 1 Cylinder-Cylinder (internal)

   EXAMPLE 2 Plane-Cylinder

b) non-conformal (counterformal): radii of curvature of the two solids in opposite directions.

   EXAMPLE 3 Sphere-Cylinder

   EXAMPLE 4 Cylinder-Cylinder (external)

Point contact	Linear contact	Contact of apparent surfaces
Reciprocal movement		
Continuous movement		
CEE Cylinder-Cylinder (external) SC Sphere-Cylinder SP Sphere-Plane SS Sphere-Sphere RR Ring-Ring	CCE Cylinder-Cylinder (external) CCI Cylinder-Cylinder (internal) PC Plane-Cylinder	CCI Cylinder-Cylinder (internal) PP Plane-Plane

Figure 1 — Contact modes most frequently used in tribometers

3.5 Friction and wear characteristics

3.5.1 Friction-measuring quantities

a) friction force, F_t;

b) coefficient of friction, μ.

3.5.2 Wear-measuring quantities

a) total amount of wear (change in mass, volume or dimensions);

b) wear resistance (reciprocal of the preceding quantity);

c) mean rate of wear: ratio of the total amount of wear to the test duration, t;

d) mean wear/distance ratio: ratio of the total amount of wear to the distance run.

3.5.3 Appearance of wear (voir Figure 2)

Pits	Localized surface cavities of small dimensions. EXAMPLE Surface defects caused by localized adherence or by the release of particles of material by a process of fatigue.	
Waves	Regularly repeated form of surface change in the form of a) depressions EXAMPLE Surface defects due to erosion by the flow of liquids. or b) bulges EXAMPLE Schallamach pattern occurring during wear of flexible plastics.	
Flakes (spalling)	Superimposed surface layers. EXAMPLE Portions of material transferred by adherence.	

Figure 2 — Types of geometrical change that occur during wear

Scratches	Scoring type of surface defect, of small extent and limited length. EXAMPLE Local effect of a hard, abrasive particle.	
Depressions	Smooth cavities in the surface, of rounded or polygonal shape. EXAMPLE Surface defects due to flow of liquid as a result of cavitation.	
Protuberances	Localized surface elevations, rounded or sharp-angled, adhering or loose. EXAMPLE Particles of material transferred by the process of adherence.	
Scoring	Wear marks in the direction of sliding in the form of grooves. EXAMPLE Marking by a hard particle acting as an abradant.	
Cracks	Localized separation from the structure of material of fine width but often of significant length and depth. EXAMPLE Evidence of surface fatigue.	
Grooving (ridging wear)	Wear marks in the form of long parallel grooves. The width of each groove is relatively constant, but this dimension, as well as the profile of the groove, may vary from one groove to another. EXAMPLE Defect resulting from plastic flow of the sub-surface layer.	

Figure 2 — Types of geometrical change that occur during wear (*continued*)

4 Purposes of friction and wear tests

4.1 General

Friction and wear tests are often performed to meet the needs described in 4.2 to 4.5.

4.2 Determination of friction characteristics of a given material

In contact with a range of different materials and in different modes of contact (see Figure 1).

4.3 Selection of material combination for a given application

By use of a test method that simulates as nearly as possible the expected application conditions.

4.4 Comparison of materials of relatively similar natures

NOTE Comparison of dissimilar materials may be desirable but is often misleading without consideration of other properties that can affect wear.

4.5 Quality control tests

For different production batches to provide assurance that the wear behaviour of the materials remains constant. For such tests, the second material of the pair shall remain the same.

5 Standard test methods

It is desirable to use only a restricted number of standard test methods that reflect as wide a range of application conditions as possible.

Bibliography

The following documents were taken into account when preparing this International Standard:

[1] *Friction, Wear and Lubrication — Glossary*, OECD, 1969 (reprinted as part of the *Wear Control Handbook* by the American Society of Mechanical Engineers, Editors: PETERSON, M.B., and WIMER, W.O.)

[2] BOWDEN, F.P., and TABOR, D., *Friction and Lubrication of Solids*, Vol. 2, Oxford University Press

[3] ISO 4378-2, *Plain bearings — Terms, definitions and classification — Part 2: Friction and wear*

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