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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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## 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.

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.

International Standard ISO 6601 was prepared by Technical Committee ISO/TC 61, *Plastics*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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

## 0 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.

The preparation of this document has taken into account the OECD publication, *Friction, Wear and Lubrication — Glossary*, 1969<sup>1)</sup>, and the definitions of terms given in ISO 4378-2, relating to plain bearings.<sup>2)</sup>

## 1 Scope and field of application

This International Standard identifies the parameters associated with the friction and wear of plastics and the conditions that the 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 References

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

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

## 3 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.<sup>3)</sup>

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

- 1) Intrinsic parameters relating to the materials involved, such as their nature, physico-chemical state, surface condition and finish.
- 2) 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 substances (lubricant, wear debris).
- 3) Parameters depending on both the nature of the materials involved and the sliding conditions, particularly surface temperature of the rubbing surfaces.

## 4 Analysis of friction and wear tests

Friction and wear processes can be described by systematic analysis of the following parameters.

### 4.1 Technical function of tribological systems

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

### 4.2 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,  $t$ .

1) This Glossary has been reprinted as part of the *Wear Control Handbook* by the American Society of Mechanical Engineers — Editors: PETERSON, M.B. and WIMER, W.O.

2) See also BOWDEN, F.P. and TABOR, D. *Friction and Lubrication of Solids*, vol. 2, published by Oxford University Press.

3) 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.

### 4.3 Structure of tribological systems

#### 4.3.1 Elements

- a) body;
- b) counter-body;
- c) interfacial medium;
- d) surrounding medium.

#### 4.3.2 Properties of the elements

- a) bulk properties (chemical composition, physical characteristics, mechanical properties, hardness);
- b) surface properties (roughness and physico-chemical characteristics).

#### 4.3.3 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).

### 4.4 Friction and wear characteristics

#### 4.4.1 Friction-measuring quantities

- a) friction force,  $F_f$ ;
- b) coefficient of friction,  $\mu$ .

#### 4.4.2 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.

#### 4.4.3 Appearance of wear (see figure 2)

### 5 Purposes of friction and wear tests

Friction and wear tests are often performed to meet the following needs:

**5.1 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).

**5.2 Selection of material combination for a given application** by use of a test method that simulates as nearly as possible the expected application conditions.

**5.3 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.

**5.4 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.

### 6 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.

	Point contact	Linear contact	Contact of apparent surfaces
Reciprocal movement			
Continuous movement			
	<p>CCE Cylinder-Cylinder (external)</p> <p>SC Sphere-Cylinder</p> <p>SP Sphere-Plane</p> <p>SS Sphere-Sphere</p>	<p>CCE Cylinder-Cylinder (external)</p> <p>CCI Cylinder-Cylinder (internal)</p> <p>PC Plane-Cylinder</p>	<p>CCI Cylinder-Cylinder (internal)</p> <p>PP Plane-Plane</p>

Figure 1 – Contact modes most frequently used in tribometers

These contacts may also be classified as follows:

- 1) Conformal. Radii of curvature of the two solids in the same direction.  
*Examples:* Cylinder-Cylinder (internal); Plane-Cylinder.
- 2) Non-conformal (counterformal). Radii of curvature of the two solids in opposite directions.  
*Examples:* Sphere-Cylinder; Cylinder-Cylinder (external).

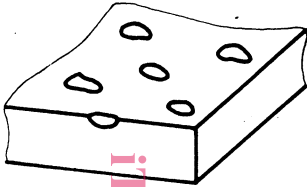
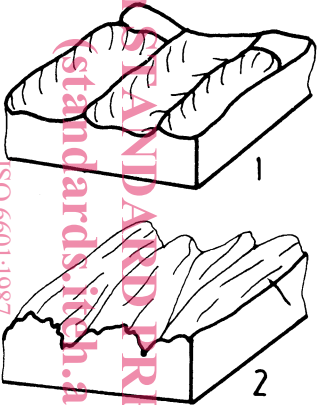
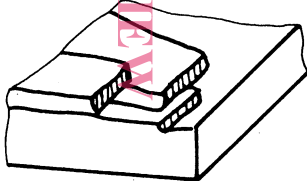
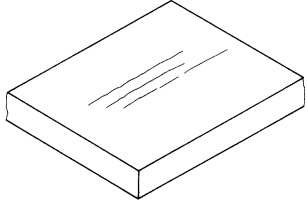
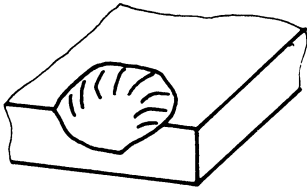
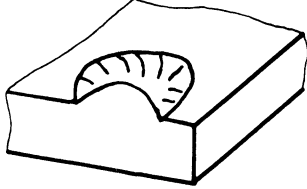
<p><b>Pits</b></p>	<p>Localized surface cavities of small dimensions.  <i>Example:</i> surface defects caused by localized adherence or by the releasing of particles of material by a process of fatigue.</p>	
<p><b>Waves</b></p>	<p>Regularly repeated form of surface change in the form of</p> <ol style="list-style-type: none"> <li>1) depressions.  <i>Example:</i> surface defects due to erosion by the flow of liquids.</li> </ol> <p>or</p> <ol style="list-style-type: none"> <li>2) bulges.  <i>Example:</i> Schallamach pattern occurring during wear of flexible plastics.</li> </ol>	
<p><b>Flakes (Spalling)</b></p>	<p>Superimposed surface layers.  <i>Example:</i> portions of material transferred by adherence.</p>	
<p><b>Scratches</b></p>	<p>Scoring type of surface defect, of small extent and limited length.  <i>Example:</i> local effect of a hard, abrasive particle.</p>	
<p><b>Depressions</b></p>	<p>Smooth cavities in the surface, of rounded or polygonal shape.  <i>Example:</i> surface defects due to flow of liquid in consequence of cavitation.</p>	
<p><b>Protuberances</b></p>	<p>Localized surface elevations, rounded or sharp-angled, adhering or loose.  <i>Example:</i> particles of material transferred by the process of adherence.</p>	

Figure 2 — Types of geometrical change that occur during wear

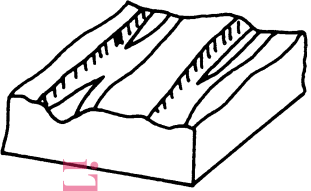

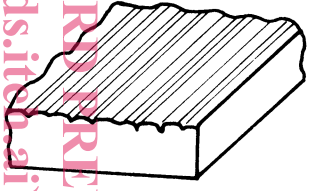
<p><b>Scoring</b></p>	<p>Wear marks in the direction of sliding in the form of grooves.  <i>Example:</i> marking by a hard particle acting as an abradant.</p>	
<p><b>Cracks</b></p>	<p>Localized separation from the structure of material of fine width but often of significant length and depth.  <i>Example:</i> evidence of surface fatigue.</p>	
<p><b>Grooving (Ridging wear)</b></p>	<p>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.  <i>Example:</i> defect resulting from plastic flow of the sub-surface layer.</p>	

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

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