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Plastics — Determination of abrasive wear by reciprocating linear sliding motion

Plastiques — Détermination de la résistance à l'abrasion par la méthode du panneau d'essai en va-et-vient

Reference number
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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 2, *Mechanical behaviour*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This corrected version of ISO 20329:2020 incorporates the following corrections:

— in the introduction, minor editorial corrections have been applied;

— in Clause 4 and 8.1, editorial corrections have been applied to clarify the procedure;

— in 8.2, a note regarding the number of reciprocations has been added.

Introduction

The reciprocating test specimen method is an abrasive wear test, based on frictional force generated at the contact surface between test specimen and abrasive material. Frictional force is applied repeatedly over the wear surface, by an abrasive material under load being applied to it in a perpendicular direction and horizontal reciprocating motion of test specimen. In this test method, abrasive wear resistance is usually evaluated by measuring wear mass per unit number of reciprocations or by specific wear rate, which is wear mass per unit load and unit sliding distance. Specific wear rate is one parameter for evaluating wear resistance in the field of tribology.

When conducting abrasive wear tests with abrasive contact, it is important to take into consideration the changes in grinding force of the abrasive material due to clogging. In this test method, an abrasive material is attached to the circumference of a wheel. The wheel itself is rotated by a small angle for each reciprocating motion (the wheel does not rotate during the reciprocating motion). Therefore, after each reciprocating motion, unused section of the abrasive material comes in contact with the test specimen. Also, the test specimen is installed with the surface to be tested facing down, where the abrasive material is placed into contact from underneath the test specimen, and wear particles or debris are not likely to collect in the wear surface. Due to the above factors, the influence of changes in grinding force of abrasive material due to clogging on test results is reduced, and wear mass per unit number of reciprocations is consistent. As a result, specific wear rate irrespective of sliding distance can be obtained.

Plastics — Determination of abrasive wear by reciprocating linear sliding motion

1 Scope

This document specifies a test method for the determination of abrasive wear resistance of plastics using abrasive material on a reciprocating motion. It also specifies calculation method for specific wear rate.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 291, *Plastics — Standard atmospheres for conditioning and testing*

ISO 80000-1:2009, *Quantities and units — Part 1: General*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
abrasive wear
progressive loss of material from the abrading surface of a plastics material resulting from the cutting or scratching action of the abrasive contact

3.2
load
W
force applied to the specimen

Note 1 to entry: Expressed in units of N.

3.3
wear resistance
R
resistance to wear, which is expressed as wear mass per reciprocation in this test method

Note 1 to entry: Expressed in the unit of "mg / reciprocation" [see 8.2, Formula (1)].

Note 2 to entry: This mass is actually force measured in a scale.

3.4
specific wear rate
w_s
wear mass per unit sliding distance and unit load

Note 1 to entry: Expressed in the unit of "mg / N•m" [see 8.3, Formula (3)].

Note 2 to entry: This mass is actually force measured in a scale.

4 Principle

A test specimen is installed horizontally onto a specimen stage so that the test surface faces down, and the test surface is abraded from below. The test specimen is fixed in place by being pressed against the specimen stage from above with a specimen holder, in order to maintain the horizontal position on the specimen stage.

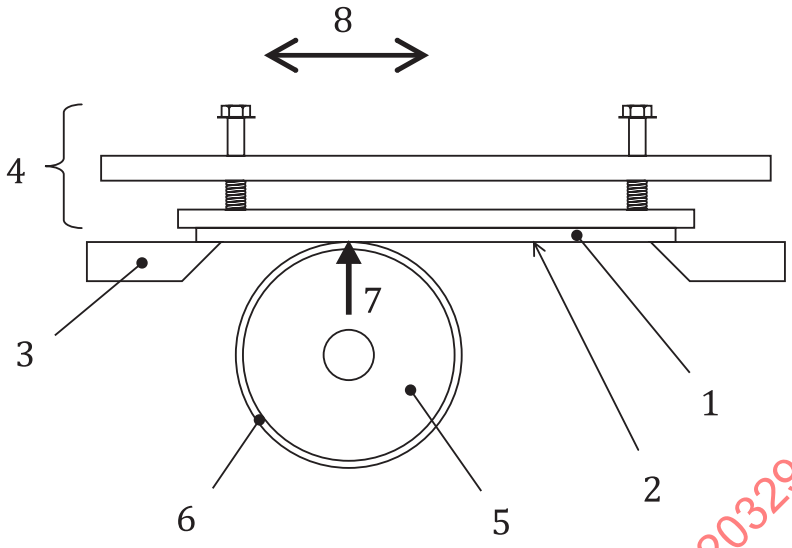
A section of an abrasive material in strip form, which is attached to the circumference of the wheel by avoiding any overlaps or gaps, comes in contact with the installed test specimen from underneath. A load is applied onto the abrasive contact from below in perpendicular upward direction. With the specimen stage, along with the test specimen, going through reciprocating motions in horizontal direction with a specified stroke length, frictional force in the horizontal direction between the test specimen and the abrasive material is generated. The reciprocating motions are repeated at a specified reciprocating frequency (reciprocation / min), and the frictional force is applied repeatedly to the same wear surface, and the wear of the test specimen continues to progress with the increased number of reciprocations.

At the completion of each reciprocating motion of the test specimen, the wheel rotates 0,9° to expose an unused section of the abrasive material to contact the specimen. The wheel does not rotate during reciprocating motions. When the wheel finishes making a full rotation, the abrasive material is replaced so that the same section of the abrasive material is never reused again.

Figure 1 describes this principle. The mass of test specimen is measured after preliminary abrasion and after the main test. The wear mass is calculated from the difference in the measured values.

NOTE 1 The method of installing test specimen with its test surface facing down is developed in order to minimize the amount of wear debris collected on the wear surface of the test specimen.

NOTE 2 A wheel is used in order to present unused section of abrasive material as contact surface. Abrasive wear in this test method is due to sliding friction and not due to rolling friction.



Key

1 test specimen
2 surface of the test specimen
3 specimen stage
4 specimen holder
5 wheel
6 abrasive material
7 load
8 reciprocating motion of specimen stage and test specimen

Figure 1 — Principle of reciprocating test specimen method

5 Apparatus

5.1 Test apparatus

The test apparatus shall consist of specimen stage, specimen holder, test specimen setting guide, wheel, loading system, and a linear reciprocating motion system.

The specimen stage shall enable test specimen to be installed horizontally, and shall have an opening to allow abrasive material to come in contact with test specimen from underneath.

The specimen holder shall be capable of maintaining the horizontal position of test specimen on specimen stage during reciprocating motion of the specimen stage and test specimen.

The test specimen setting guide shall enable the test specimen to be repositioned in the same location on the specimen stage.

The wheel shall be made from metals having elastic modulus of at least 60 GPa with diameter of (50 ± 0,5) mm and width of (12 ± 0,2) mm. The wheel rotates 0,9° for each reciprocating motion of the specimen stage and test specimen, and makes a full round of rotation with 400 reciprocating motions.

The maximum load applied to abrasive contact by the loading system is up to 19,6 N and shall be variable with an accuracy of ± 5 %.

The linear reciprocating motion system shall be equipped for the reciprocating motion of specimen stage and test specimen. Single stroke of reciprocating motion shall be 30 mm in length, and reciprocating frequency shall be (40 ± 2) reciprocations per minute.

A typical test apparatus is indicated in Annex B.

NOTE 1 Aluminium alloy is typically used as material for the wheel.

NOTE 2 Reciprocating frequency is such that the heat generation does not affect the test result, and other reciprocating frequency is used upon the agreement between the parties involved.

5.2 Abrasive material

Silicon carbide abrasive paper as specified in ISO 6344-1 is recommended as abrasive material. It shall be in strip form with a width of (12,0 ± 0,2) mm. The length shall be such so that the wheel is covered without any overlap or gap, where 159 mm is most suitable. Use either double sided adhesive tape to attach abrasive material to wheel or abrasive material with adhesive tape backing. Other types of abrasive materials can be used under agreement between the interested parties.

5.3 Balance

Use balance with resolution of 0,1 mg.

6 Test specimens

6.1 Test specimens

Test specimens shall be flat and typically 50 mm × 50 mm, with at least 50 mm in the direction of reciprocating motion. Typical thickness of test specimens is from 1 mm to 5 mm. Test specimens specified in ISO 20753 can also be used. Determine the size of test specimens so that the mass of specimens do not exceed capacity of balances being used.

Number of specimens shall be at least 3.

6.2 Conditioning

Condition the test specimens, abrasive material and adhesive tape for at least 16 h in accordance with one of the standard atmosphere specified in ISO 291.

7 Procedures

7.1 Abrasive and load selection

Select grit size of abrasive material and value of load for conducting the tests.

Recommended grit sizes are P180, P240 and P320 specified in ISO 6344-1, and recommended load values are 3,9 N, 6,9 N, and 19,6 N.

7.2 Preparation and installation of the wheel

Attach a strip of abrasive material as recommended in 7.1 by adhesive tape of the same dimensions as the strip so that the longitudinal direction of the strip is along the circumference of the wheel. Take care that the ends of the strip do not overlap or leave gaps. After that, install the wheel to the test apparatus.

7.3 Adjustment of loading system

Set load with loading system to the load value as recommended in 7.1.

7.4 Test atmosphere

The test shall be conducted under the same conditions as was used in the conditioning of the test specimen (see 6.2).

7.5 Procedure of the preliminary abrasion

7.5.1 Carry out the preliminary abrasion in accordance with the following procedures in order to reduce the influence of different surface conditions of the test specimens.

7.5.2 Set test specimen onto specimen stage so that the contact section of abrasive material does not extend beyond the edges of the test specimen. The test specimen setting guide shall be used to ensure the test specimen can be repositioned in the same location.

7.5.3 Bring the abrasive material into contact with the test specimen with the load as adjusted in 7.3.

7.5.4 Conduct 50 reciprocations as the preliminary abrasion. Number of reciprocations and load for the preliminary abrasion can be changed under agreement between the interested parties.

7.5.5 Remove the test specimen from the specimen stage and clean wear debris from the surface of the test specimen using lint-free cloth or air blower, for example.

7.5.6 Weigh the test specimen to the nearest 0,1 mg using a balance (see 5.3).

NOTE Take care to avoid errors in mass measurement caused by static electricity generated during testing.

7.6 Procedure of the main test

7.6.1 Conduct the following steps until the difference between the mass of the specimen after preliminary abrasion and the mass of the specimen after the main test (i.e. the wear mass) is at least 10 mg.

7.6.2 Using the test specimen setting guide, align the test specimen in the same position and secure onto the test specimen stage.

7.6.3 Bring the abrasive material into contact with the test specimen, with the load as adjusted in 7.3.

7.6.4 Conduct the abrasive test. After the wheel makes a full rotation with 400 reciprocating motions (including preliminary abrasion), abrasive material shall be replaced.

7.6.5 Remove the test specimen from the specimen stage, and clean wear debris from the surface of the test specimen using lint-free cloth or air blower, for example. Weigh the test specimen to the nearest 0,1 mg using a balance (see 5.3). If the mass loss is at least 10 mg, end the test. Otherwise, repeat 7.6.2 to 7.6.5.

7.7 Test for the remaining specimens

Conduct the procedures in 7.5 and 7.6 on two or more additional test specimens for the same number of reciprocations as for the first test specimen.

8 Evaluation of the main test

8.1 Wear mass

Wear resistance and specific wear rate can be obtained by calculating wear mass of each test specimen from the difference between the mass measurements after preliminary abrasion and after the main test (see 7.6).

8.2 Wear resistance

Calculate wear resistance of each test specimen from wear mass in 8.1 as shown in Formula (1).

$$R=\frac{M}{N} \tag{1}$$

where

R is the wear resistance (mg / reciprocation);

M is the wear mass (mg);

N is the number of reciprocations.

NOTE N does not include the reciprocations generated during the preliminary abrasion.

8.3 Specific wear rate

Calculate sliding distance using Formula (2).

$$L=60\times10^{-3}\times N \tag{2}$$

where L is the sliding distance (m).

Calculate specific wear rate of each test specimen from wear mass and sliding distance using Formula (3).

$$w_s=\frac{M}{W\times L} \tag{3}$$

where

w_s is the specific wear rate (mg / N•m);

M is the wear mass (mg);

W is the load (N).

9 Precision

See Annex A.

10 Test report

The test report shall include the following information.

a) a reference to this document, i.e. ISO 20329:2020;

b) details necessary to identify and characterize the test specimen;

c) width of wear area;

d) number of test specimens;

e) grit size of abrasive material;

f) load, in newtons;

g) number of reciprocations in the preliminary abrasion;

h) total number of reciprocations for main test;

i) 3 or more individual wear mass and their average (according to 8.1) rounded to an integer according to ISO 80000-1:2009, Annex B;

j) 3 or more individual wear resistance and their average (according to 8.2);

k) 3 or more individual specific wear rate and their average (according to 8.3);

l) any deviations from the specified test method;

m) any unusual observation during the test;

n) the date of test.

Annex A
(informative)

Precision

A.1 Definitions and information

A.1.1 Tables A.1 to A.3 are based on a round-robin test involving five laboratories and five materials. Test specimens were injection-moulded and distributed by one laboratory. Each laboratory obtained and reported three individual test results for each material. The results reported have been evaluated according to ISO 5725-2.

A.1.2 The test conditions were the following:

— type of specimen: multipurpose specimen specified in ISO 20753 (specimen type A1)

— grid size of abrasive paper: P180 specified in ISO 6344-1

— load: 6,9 N

— number of reciprocations in the preliminary abrasion: 200 reciprocations

— width of wear area: 10 mm

A.1.3 The concept of "*r*" and "*R*" can be seen in Tables A.1 to A.3.

A.1.3.1 Repeatability – Two test results obtained within one laboratory should be judged not equivalent if they differ by more than the *r* value for that material. *r* is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment in the same laboratory.

A.1.3.2 Reproducibility – Two test results obtained by different laboratories should be judged not equivalent if they differ by more than the *R* value for that material. *R* is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

A.1.3.3 The judgments in A.1.3.1 and A.1.3.2 will have approximately 95 % (0,95) probability of being correct.

A.2 Precision data

In Tables A.1 to A.3, the statistical properties used are:

s_r = within-laboratory standard deviation,

s_R = between-laboratories standard deviation,

r = 95 % repeatability limit = $2{,}8 s_r$,

R = 95 % reproducibility limit = $2{,}8 s_R$,

n_{Lab} = number of laboratories

Table A.1 — Precision, wear mass (mg)

		400 reciprocations				
Material	n_{Lab}	Average	s_r	s_R	r	R
PP	5	16,3	0,6	3,1	1,7	8,7
PE	5	17,3	0,6	0,6	1,7	1,7
PC	5	21,0	0,4	0,8	1,1	2,2
PS	5	33,8	0,9	1,2	2,5	3,4
PMMA	5	39,0	0,6	1,9	1,7	5,3
		600 reciprocations				
Material	n_{Lab}	Average	s_r	s_R	r	R
PP	5	24,7	0,6	4,6	1,7	12,9
PE	5	26,6	1,0	1,1	2,8	3,1
PC	5	31,0	0,5	0,9	1,4	2,5
PS	5	50,1	0,9	1,7	2,5	4,8
PMMA	5	57,4	0,8	2,6	2,2	7,3

Table A.2 — Precision, wear resistance (mg / reciprocation)

		400 reciprocations				
Material	n_{Lab}	Average	s_r	s_R	r	R
PP	5	0,040 8	0,001 6	0,007 8	0,004 5	0,021 8
PE	5	0,043 2	0,001 4	0,001 6	0,003 9	0,004 5
PC	5	0,052 6	0,000 9	0,001 9	0,002 5	0,005 3
PS	5	0,084 5	0,002 3	0,003 1	0,006 4	0,008 7
PMMA	5	0,097 4	0,001 6	0,004 7	0,004 5	0,013 2
		600 reciprocations				
Material	n_{Lab}	Average	s_r	s_R	r	R
PP	5	0,041 2	0,001 1	0,007 7	0,003 1	0,021 6
PE	5	0,044 3	0,001 7	0,001 8	0,004 8	0,005 0
PC	5	0,051 7	0,000 8	0,001 5	0,002 2	0,004 2
PS	5	0,083 4	0,001 5	0,002 9	0,004 2	0,008 1
PMMA	5	0,095 6	0,001 4	0,004 3	0,003 9	0,012 0

Table A.3 — Precision, specific wear rate (mg / N•m)

		400 reciprocations				
Material	n_{Lab}	Average	s_r	s_R	r	R
PP	5	0,098	0,004	0,019	0,011	0,053
PE	5	0,104	0,003	0,004	0,008	0,011
PC	5	0,127	0,002	0,005	0,006	0,014
PS	5	0,204	0,006	0,008	0,017	0,022
PMMA	5	0,235	0,004	0,011	0,011	0,031
		600 reciprocations				
Material	n_{Lab}	Average	s_r	s_R	r	R
PP	5	0,100	0,003	0,018	0,008	0,050
PE	5	0,107	0,004	0,004	0,011	0,011
PC	5	0,125	0,002	0,004	0,006	0,011
PS	5	0,202	0,004	0,007	0,011	0,020
PMMA	5	0,231	0,003	0,010	0,008	0,028

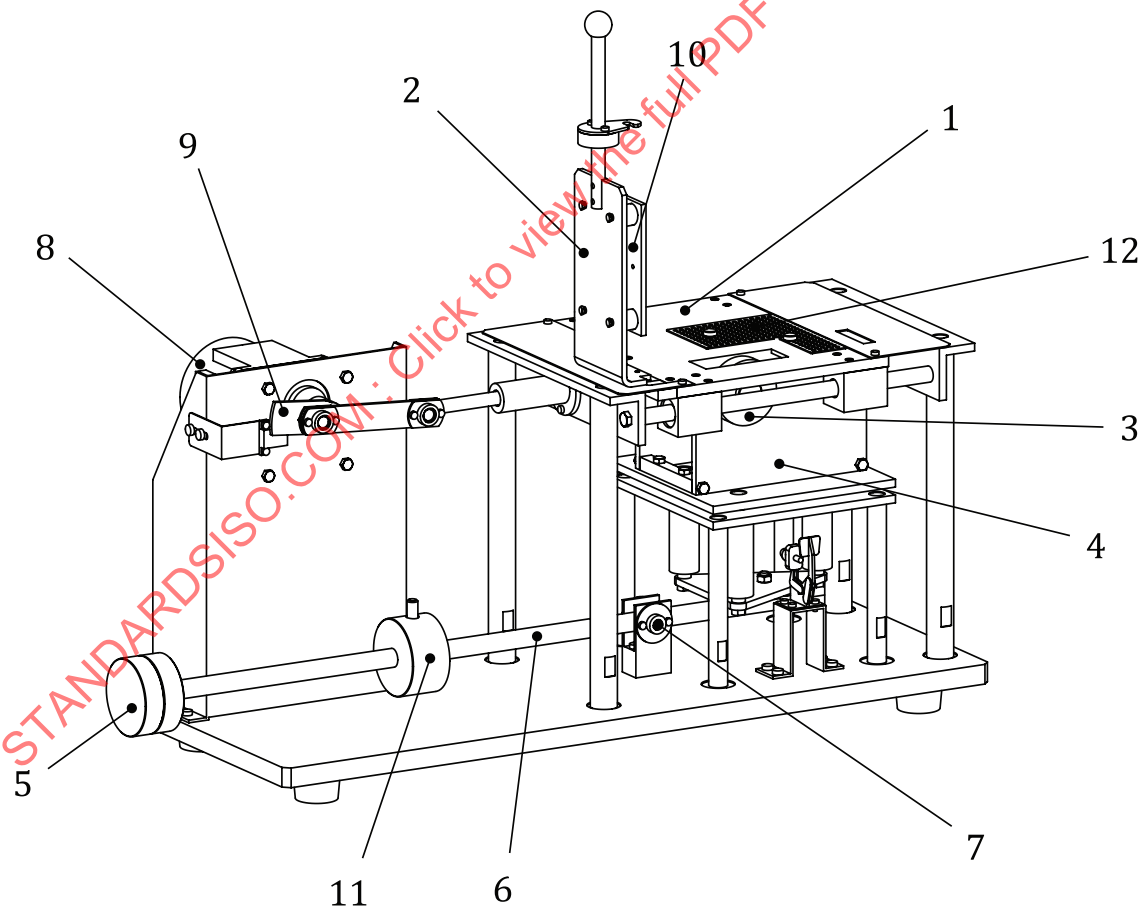
Annex B
(informative)

Typical test apparatus

A suitable test apparatus for this document has been developed by Suga Test Instruments Co., Ltd., Japan. This test apparatus complies with the specifications of this document and has been used in the round-robin test shown in Annex A. Figure B.1 shows the schematic view of the test apparatus.

The adjustable loading system of the test apparatus is based on weight and lever applying the load. Adjustment of load is performed by sliding moveable weight (load adjuster) on the shaft of the lever, thereby changing the distance between the effort and the fulcrum on the lever. The wheel is rotated by a stepper motor, and the linear reciprocating motion system for the specimen stage and test specimen consists of reciprocating motion motor and crank.

This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this test apparatus.



Key

1	specimen stage	5	weight	9	crank
2	specimen holder	6	lever	10	plate
3	wheel	7	fulcrum	11	load adjuster
4	stepper motor case	8	reciprocating motion motor	12	test specimen setting guide

Figure B.1 — Schematic view of test apparatus