INTERNATIONAL STANDARD

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Third edition
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Rubber, vulcanized or thermoplastic — Determination of tendency to adhere to and corrode metals

Caoutchouc, vulcanisé ou thermoplastique — Détermination de la tendance à adhérer aux métaux et à les corroder

Reference number
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Foreword

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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 6505 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This third edition cancels and replaces the second edition (ISO 6505:1997), which has been extended to include a specification for a “wet” atmosphere and to cover the testing of O-rings.

Introduction

In assemblies which include both metallic and rubber components, it is essential to avoid unintentional adhesion of rubber to metal, and corrosion of the metal by the rubber. Adhesion occurs only where there is direct contact between the metal and the rubber, but corrosion may also arise, within a closed system, on metal components remote from the rubber, such corrosion being due to volatile materials emanating from the rubber.

Since some metals corrode more readily than others, it is not possible to specify optimum test conditions for assessing the resistance to corrosion of all metals and alloys. Furthermore, the ranking of a metal's susceptibility to corrosion will depend upon the environment in which it is exposed to the rubber, e.g. in the presence of high humidity the effects on steel, in particular, can be severe.

Rubber, vulcanized or thermoplastic — Determination of tendency to adhere to and corrode metals

WARNING — Persons using this International Standard should be familiar with normal laboratory practice. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with any national regulatory conditions.

1 Scope

This International Standard specifies a method for the determination of the tendency of vulcanized or thermoplastic rubbers to adhere to and to corrode metals when exposed to a specified test environment.

The calibration schedule necessary for the apparatus used for this type of measurement is included in Annex A.

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 48, *Rubber, vulcanized or thermoplastic — Determination of hardness (hardness between 10 IRHD and 100 IRHD)*

ISO 209-1, *Wrought aluminium and aluminium alloys — Chemical composition and forms of products — Part 1: Chemical composition*

ISO 630, *Structural steels — Plates, wide flats, bars, sections and profiles*

ISO 3310-1, *Test sieves — Technical requirements and testing — Part 1: Test sieves of metal wire cloth*

ISO 18899:2004, *Rubber — Guide to the calibration of test equipment*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

EN 1652, *Copper and copper alloys — Plate, sheet, strip and circles for general purposes*

3 Principle

Rubber test pieces are held between metal test strips under specified conditions in a dry or wet atmosphere for a specified period.

Subsequent visual examination of the metal surface provides a subjective indication of the degree of adhesion to the metal by the rubber and corrosion of the metal.

4 Materials

4.1 **Acetone** (for cleaning of metal), of recognized analytical quality.

4.2 **Other suitable solvents** (for cleaning of rubber), of recognized analytical quality and which do not have any deleterious effects on the rubber under test.

4.3 **Pumice powder**, passing a test sieve of nominal aperture size 53 µm complying with the requirements of ISO 3310-1.

4.4 **Distilled water** or water of equivalent purity.

4.5 **Silica gel**.

5 Apparatus

5.1 Usual laboratory equipment, plus the following:

5.2 **Support jig**, to align the metal test strips and rubber test pieces, capable of supporting the clamping force, and with a facility for setting clamps to maintain the clamping force on the assembled test piece "sandwich" throughout the test period (see Figure 1).

5.3 **Test chamber**, complying with the requirements specified in ISO 23529, with facilities for controlling the temperature within the tolerance limits given in ISO 23529.

For tests other than those in a "dry" atmosphere, a suitable means for controlling the humidity to within the tolerance limits given in ISO 23529 shall be provided.

NOTE 1 For tests in a "dry" atmosphere (less than 10 % humidity), a desiccator may be used. For tests at elevated temperature, it is common practice to assume low humidity.

NOTE 2 For tests in a "wet" atmosphere (approximately 90 % humidity), a desiccator may be used with an open vessel at the bottom containing a mixture of 33 parts by mass of glycerol and 67 parts by mass of water. The relative density of this mixture will be 1,080 6 at 20 °C. The relative humidity above its surface will be approximately 90 % at 23 °C.

5.4 **Polyethylene gloves**, or other suitable equipment to prevent direct contact with the test surfaces.

5.5 **Magnifying glass**, of magnification ×3 to ×5.

5.6 **Weights**, with flat bottoms.

6 Test metals

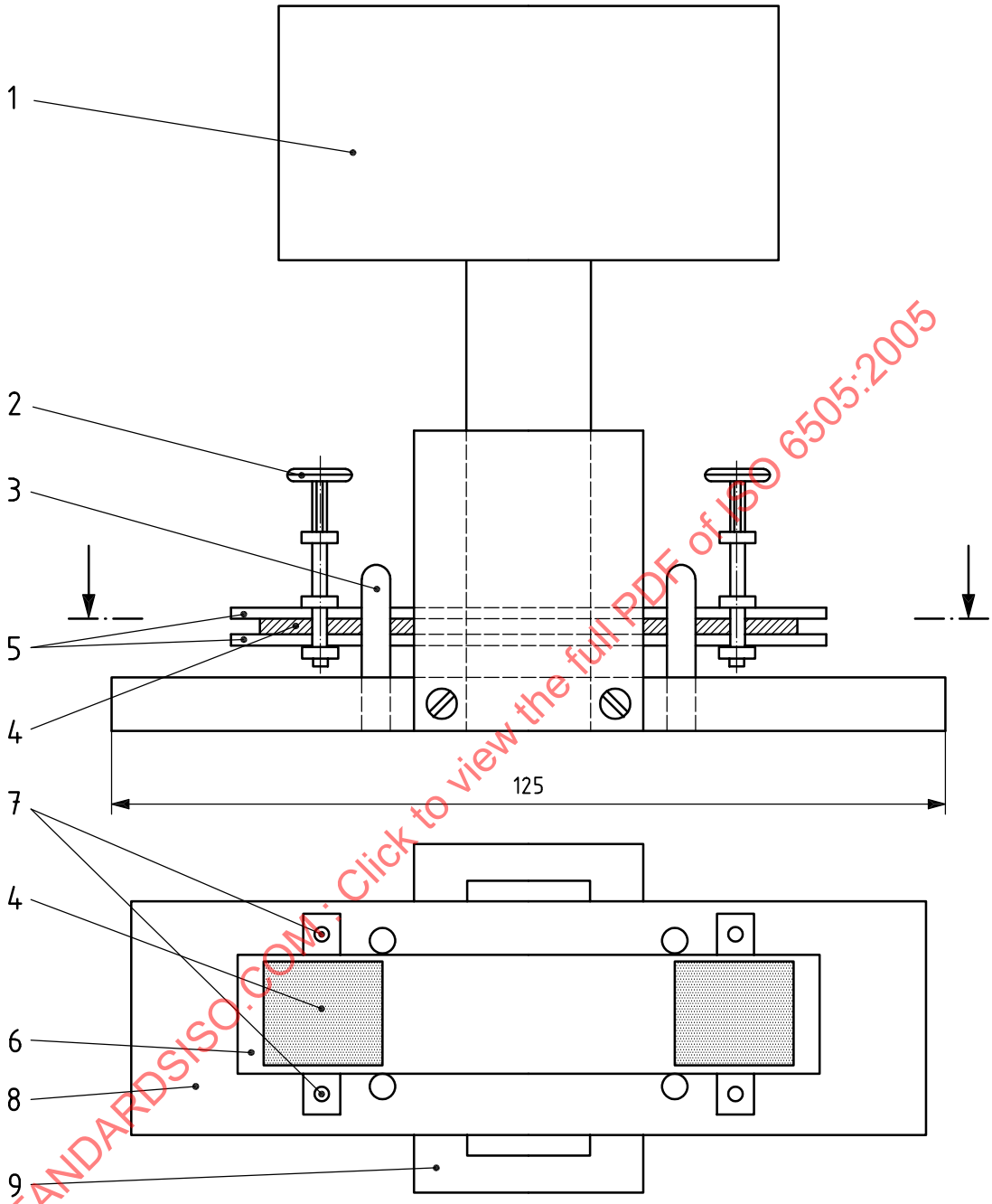
The test metals used shall be those specified in the relevant material specification. If the metals are not specified, they shall be selected from the standard test metals specified in Table 1.

Table 1 — Standard test metals

Standard test metal	Description
Aluminium	ISO 209-1: Grade Al Cu4SiMg, condition TF
Carbon steel	ISO 630: Grade Fe 360A

NOTE If brass (CuZn37) or copper (Cu-ETP) is used, it can be described in accordance with EN 1652, for example.

Dimensions in millimetres



Key

1	10 kg weight	4	rubber test piece	7	positions of clamps
2	screw clamp	5	metal test strips	8	support base
3	locating pin	6	bottom metal test strip	9	guides for 10 kg weight

Figure 1 — Typical support jig

The metal test strips shall have a thickness sufficient to withstand the clamping force without bending. If only thin foil is available, it shall be supported by a rigid backing material previously shown to be non-corrosive to the test metals.

The test metals shall be in the form of strips with dimensions as given in Table 2:

Table 2 — Dimensions of metal test strips

Width mm	Length (min.) mm	Comments
25 ± 1	100	For use with square test pieces measuring 20 mm × 20 mm
50 ± 1	100	For use with O-rings with an outer diameter of 18 mm to 45 mm

7 Test pieces

7.1 Preparation

7.1.1 Square test pieces

Square test pieces shall be (20 ± 0,5) mm × (20 ± 0,5) mm and preferably with a thickness of (2,0 ± 0,2) mm. They shall be cut or punched from sheet or from the product under evaluation in accordance with ISO 23529.

7.1.2 O-ring test pieces

O-ring test pieces shall have a cross-sectional diameter of (3,55 ± 0,1) mm. The outer diameter of the test piece shall be min. 18 mm and max. 45 mm.

7.2 Number

At least two test pieces shall be used for each test.

7.3 Time-interval between forming the material and testing

The time-interval between forming the material and testing shall be in accordance with ISO 23529.

7.4 Storage

Samples and test pieces shall be protected from light as completely as possible during the interval between forming and testing.

8 Test conditions

8.1 Temperature

The test temperature shall be selected from the list in ISO 23529.

8.2 Test period

The duration of the test shall be selected from the following: $24^{\ 0}_{-2}$ h; $72^{\ 0}_{-2}$ h; (96 ± 2) h; (120 ± 2) h; (168 ± 2) h and multiples of 7 days.

NOTE The test period of 120 h has been included alongside periods from ISO 23529 because it is used in material specifications, especially for testing in a wet atmosphere.

8.3 Humidity

In terms of humidity, the atmosphere shall be

a) either a dry atmosphere having a relative humidity of less than 10 %,

b) or a wet atmosphere having a relative humidity of (90 ± 5) %.

NOTE This test is commonly carried out at low humidity to ensure that corrosion resulting from causes other than those due to the rubber is minimized.

9 Procedure

9.1 Precaution

In all operations, it is essential that the rubber test pieces and the metal test strips are handled only by means of the polyethylene gloves or other protective equipment (see 5.4). This precaution is essential in order to minimize surface contamination of the test piece and metal strips.

9.2 Preparation of rubber test pieces for testing

Clean all the surfaces of the rubber test pieces with cotton wool pads moistened with a suitable solvent (see 4.2) to remove surface contamination (by mould release agents, for example). The solvent to be used will depend on the rubber under test; it shall not have any deleterious effects on the rubber (e.g. acetone should not be used for nitrile rubber; isopropyl alcohol is preferred for this material).

Allow the test pieces to dry in air. When dry, store the test pieces, unless otherwise specified, in a clean desiccator over silica gel at standard laboratory temperature (see ISO 23529) for at least 24 h immediately prior to testing.

Since cleaning of the test pieces may also remove from the rubber surface materials such as waxes, antiozonants, etc., which would normally be expected to affect the adhesion and corrosion properties of the rubber, allow sufficient time in the desiccator for the re-formation of the “original” surface before testing.

9.3 Number of metal test strips

For each test, use two suitable metal test strips as specified in the material specification or selected from the metals specified in Clause 6.

For tests in a wet atmosphere, only like metals shall be used in the construction of the test piece “sandwich” in order to avoid electrolytic effects.

9.4 Preparation of surfaces of metal test strips

Thoroughly scour the test surfaces of the metal test strips using a slurry of pumice powder (4.3) in water applied with a cotton wool pad until a matt surface is obtained. Thoroughly rinse the metal strips with water (4.4) and then with acetone (4.1) and finally dry in air. If the prepared metal test strips are not to be used immediately after cleaning, store them in a clean desiccator over silica gel for not more than 24 h before testing.

9.5 Determination

9.5.1 Tests in a dry atmosphere

9.5.1.1 Tests using sheet material (square test pieces)

Take two rubber test pieces as specified in 7.1.1, prepared as specified in 9.2, and two metal strips of dimensions 25 mm by 100 mm, prepared as specified in 9.4. Place the two pieces of rubber between the prepared surfaces of the metal strips so that they are approximately 40 mm apart and equidistant from the ends (see Figure 1). Align the rubber/metal sandwich so formed in the support jig and apply a (10 ± 0,1) kg weight (equivalent to 122,5 kPa acting on the rubber) to the test piece sandwich. Tighten the two screws, one at each end of the sandwich, with just sufficient force to maintain the clamping force when the 10 kg weight is removed. Remove the 10 kg weight from the jig, place the sandwich in the test chamber (5.3) and maintain it at the test temperature for the test period (see Clause 8).

At the end of the test period, remove the sandwich from the test chamber, allow to cool, if appropriate, to standard laboratory temperature and maintain it at this temperature for at least 1 h. Release the screw clamps and carefully separate the metal strips from the rubber test pieces. Examine the surface of the metal previously in contact with the rubber for signs of adhesion and corrosion. Use a magnifying glass (5.5) in examining for corrosion.

9.5.1.2 Tests using O-rings

Take two O-rings of the same size, as specified in 7.1.2, prepared as specified in 9.2, and two metal strips of dimensions 50 mm by 100 mm, prepared as specified in 9.4. Place the O-rings between the prepared surfaces of the metal strips so that they are approximately 40 mm apart and approximately equidistant from the ends of the metal strips. Align the metal/rubber sandwich so formed in the support jig and apply a load L in accordance with Table 3 to the test piece sandwich. Tighten the two screw clamps, one at each end of the sandwich, with just sufficient force to maintain the clamping force when the load is removed. Remove the load from the jig, place the sandwich in the test chamber (5.3) and maintain it at the test temperature for the test period (see Clause 8).

At the end of the test period, remove the sandwich from the test chamber, allow to cool, if appropriate, to standard laboratory temperature and maintain it at this temperature for at least 1 h. Release the screw clamps and carefully separate the metal strips from the rubber O-rings. Examine the surface of the metal previously in contact with the rubber for signs of adhesion and corrosion. Use a magnifying glass (5.5) in examining for corrosion.

9.5.2 Tests in a wet atmosphere

9.5.2.1 Tests using sheet material (square test pieces)

Take two rubber test pieces as specified in 7.1.1, prepared as specified in 9.2, and two metal strips of dimensions 50 mm by 100 mm, prepared as specified in 9.4. Place the two pieces of rubber between the prepared surfaces of the metal strips so that they are approximately 40 mm apart and equidistant from the ends (see Figure 1). Align the rubber/metal sandwich so formed in the support jig and apply a (10 ± 0,1) kg weight (equivalent to 122,5 kPa acting on the rubber) to the test piece sandwich. Tighten the two screws, one at each end of the sandwich, with just sufficient force to maintain the clamping force when the 10 kg weight is removed. Remove the 10 kg weight from the jig, place the sandwich in the test chamber (5.3) and maintain it at the standard laboratory temperature and a relative humidity of (90 ± 5) % for the test period (see 8.2).

At the end of the test period, remove the sandwich from the test chamber, release the screw clamps and carefully separate the metal strips from the rubber test pieces. Keep the metal strips in an atmosphere at standard laboratory temperature and a relative humidity of (50 ± 5) % for 16 h to 24 h. At the end of this period, examine the surface of the metal previously in contact with the rubber for signs of adhesion and corrosion. Use a magnifying glass (5.5) in examining for corrosion.

9.5.2.2 Tests using O-rings

Take two O-rings of the same size, as specified in 7.1.2, prepared as specified in 9.2, and two metal strips of dimensions 50 mm by 100 mm, prepared as specified in 9.4. Place the O-rings between the prepared surfaces of the metal strips so that they are approximately 40 mm apart and approximately equidistant from the ends of the metal strips. Align the metal/rubber sandwich so formed in the support jig and apply a load L in accordance with Table 3 to the test piece sandwich. Tighten the two screw clamps, one at each end of the sandwich, with just sufficient force to maintain the clamping force when the load is removed. Remove the load from the jig and place the sandwich in the test chamber (5.3) and maintain it at the standard laboratory temperature and a relative humidity of (90 ± 5) % for the test period (see 8.2).

At the end of the test period, remove the sandwich from the test chamber, release the screw clamps and carefully separate the metal strips from the rubber O-rings. Keep the metal strips in an atmosphere at standard laboratory temperature and a relative humidity of (50 ± 5) % for 16 h to 24 h. At the end of this period, examine the surface of the metal previously in contact with the rubber for signs of adhesion and corrosion. Use a magnifying glass (5.5) in examining for corrosion.

Table 3 — Choice of test load

Rubber hardness determined in accordance with ISO 48 IRHD	**Load per mm circumference,** ΔL N/mm	The load L required is calculated, in newtons, from the equation $L = 2 \times \Delta L \times \pi(D_i + d)$ where ΔL is the load per mm circumference, in N/mm; D_i is the inner diameter of the O-ring, in mm; d is the thickness of the O-ring, in mm; 2 allows for the fact that the load is spread over two test pieces.
50	0,4 ± 0,05	
55	0,5 ± 0,05	
60	0,6 ± 0,05	
65	0,8 ± 0,05	
70	1,1 ± 0,05	
75	1,5 ± 0,1	
80	1,9 ± 0,1	
85	2,6 ± 0,2	
90	3,3 ± 0,2	

10 Expression of results

10.1 Degree of adhesion

Evaluate the degree of adhesion in accordance with the following criteria:

a) Complete separation of rubber from both metal surfaces. No indication of any adhesion.

b) Considerable force necessary to separate the metal surfaces. Particles of rubber remain adhering to one or both metal surfaces.

10.2 Degree of corrosion

Evaluate the degree of corrosion in accordance with the following criteria:

10.2.1 For tests in a dry atmosphere:

a) No surface stain or corrosion.

b) Surfaces stained or discolouration present, but no corrosion as evidenced by pitting or erosion of one or both metal surfaces.

c) Corrosion as evidenced by pitting and erosion on one or both metal surfaces.

10.2.2 For tests in a wet atmosphere:

For that part of the metal strip which has been in contact with the test piece, the degree of corrosion shall be graded from 0 to 5 where 0 is no staining or corrosion and 5 is severe staining or corrosion. Examples of grades 1 to 5 are given for O-ring test pieces in Annex B.

11 Test report

The test report shall include the following information:

a) a reference to this International Standard;

b) sample details:

   1) a full description of the sample and its origin,

   2) compound details and curing conditions, where appropriate,

   3) the method of preparation of the test pieces from the sample,

   4) the type of metal test strip used;

c) test details:

   1) the standard laboratory temperature and humidity used,

   2) the test duration, test temperature and test atmosphere used,

   3) any deviations from the standard procedure;

d) test result: details of any adhesion and/or corrosion;

e) the date of the test.

Annex A
(normative)

Calibration schedule

A.1 Inspection

Before any calibration is undertaken, the condition of the items of apparatus to be calibrated shall be ascertained by inspection and recorded in a calibration report or certificate. It shall be reported whether calibration is made in the “as-received” condition or after rectification of any abnormality or fault.

It shall be ascertained whether the apparatus is, in general, fit for the intended purpose, including any parameters specified as approximate and for which the apparatus does not therefore need to be formally calibrated. If such parameters are liable to change, then the need for periodic checks shall be written into the detailed calibration procedures.

A.2 Calibration schedule

For each item, the calibration procedure is indicated in the schedule given in Table A.1 by the code-letter C (indicating that confirmation is necessary that the requirement is met, but no measurement is necessary) or by reference to a clause or subclause in ISO 18899.

The verification frequency for each item is given in Table A.1 by the following code-letters:

N initial verification only;

S verification at the standard interval given in ISO 18899;

U verification in use.

Table A.1 — Calibration schedule

Item	Requirement	Procedure	Verification frequency	Notes
Support jig	Capable of withstanding the clamping force throughout the test	C	N	
Test chamber	As per ISO 23529			
Temperature control	As per ISO 23529	ISO 18899:2004, Clause 18	S	
Magnification glass	×3 to ×5	C	N	
Test metal strip material:				
Aluminium	ISO 209-1: Grade Al Cu4SiMg, condition TF	C	N	
Brass	EN 1652	C	N	
Copper	EN 1652	C	N	
Carbon steel	ISO 630: Grade Fe 360A	C	N	
Other metals	As specified			
Size of test metal strip	25 mm or 50 mm wide by ⩾ 100 mm long	C	N	
Thickness of strip	Sufficient to withstand the clamping force	C	U	
if made of thin foil	Use non-corrosive rigid backing material	C	U	
Humidity	< 10 %, 50 % or 90 %	ISO 18899:2004, Clause 20	S	
If high humidity used	Use like metals in sandwich	C	U	
Preparation of rubber	Clean all surfaces with a suitable solvent having no deleterious effect on the rubber. Handle with gloves or similar.	C	U	E.g. do not use acetone on nitrile rubber
Storage	In clean desiccator over silica gel, protected from light	C	U	
Distance apart of two rubber test pieces	Approximately 40 mm	C	U	
Test load (tests on O-rings)	See Table 3	ISO 18899:2004, Subclause 21.3	S	
Applied weight (tests on square test pieces)	(10 ± 0,1) kg	ISO 18899:2004, Subclause 22.2		
Relative humidity	(50 ± 5) %	ISO 18899:2004, Clause 20	S	
Materials	Acetone of analytical quality Solvents of analytical quality (having no deleterious effect on the rubber under test) Pumice powder, passing through a sieve of nominal aperture size 53 µm complying with ISO 3310-1 Distilled water or water of equivalent purity Silica gel Polyethylene or polypropylene medical gloves or forceps			