INTERNATIONAL STANDARD

ISO 9211-3

First edition
1994-09-01

Optics and optical instruments — Optical coatings —

Part 3: Environmental durability

Optique et instruments d'optique — Traitements optiques —
Partie 3: Comportement aux essais d'environnement

Reference number
ISO 9211-3:1994(E)

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.

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.

International Standard ISO 9211-3 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 3, *Optical materials and components.*

ISO 9211 consists of the following parts, under the general title *Optics and optical instruments — Optical coatings*

— *Part 1: Definitions*

— *Part 2: Optical properties*

— *Part 3: Environmental durabiliy*

— *Part 4: Specific test methods*

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Optics and optical instruments — Optical coatings —

Part 3:
Environmental durability

1 Scope

ISO 9211 identifies surface treatments of components and substrates excluding ophthalmic optics (spectacles) by the application of optical coatings and gives a standard form for their specification. It defines the general characteristics and the test and measurement methods whenever necessary, but is not intended to define the process method.

This part of ISO 9211 specifies categories of use for optical coatings and identifies corresponding environmental tests. Definitions and the extent of testing are given in ISO 9211-1.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards

ISO 9022-1:—[1], *Optics and optical instruments — Environmental test methods — Part 1: Definitions, extent of testing.*

ISO 9022-2:—[1], *Optics and optical instruments — Environmental test methods — Part 2: Cold, heat, humidity.*

ISO 9022-4:—[1], *Optics and optical instruments — Environmental test methods — Part 4: Salt mist.*

ISO 9022-6:—[1], *Optics and optical instruments — Environmental test methods — Part 6: Dust.*

ISO 9022-9:—[1], *Optics and optical instruments — Environmental test methods — Part 9: Solar radiation.*

ISO 9022-11:—[1], *Optics and optical instruments — Environmental test methods — Part 11: Mould growth.*

ISO 9022-12:—[1], *Optics and optical instruments — Environmental test methods — Part 12: Contamination.*

ISO 9022-14:—[1], *Optics and optical instruments — Environmental test methods — Part 14: Dew, hoarfrost, ice.*

3 Categories of use

3.1 Definitions of categories

Five categories of use are given by different sets of environmental tests. The requirements for each category are qualitatively outlined below, and specified in table 1.

Category A

This refers to applications which would normally only apply to components mounted internally within sealed units. The use in this category is in a protected and controlled environment and handling should only take place with extreme care.

Category B

This refers to applications where components will be exposed only to a controlled environment. Such applications can include mild abrasion as occurs with carefully controlled cleaning.

Category C

This refers to applications where components will be exposed to normal outdoor ambient conditions and uncontrolled cleaning without severe abrasion and

1) To be published.

scratching. Typical applications would apply to external surface antireflection coatings on cameras and binoculars.

Category D

This refers to applications where components will be exposed to severe outdoor ambient conditions and uncontrolled cleaning with severe abrasion and scratching.

Category O

This refers to applications adapted to special conditons (optional).

The requirements for coatings as listed in table 1 are typically not accumulative and can be tested individually.

3.2 Modification of categories

Some intended applications of components will not exactly fit into one of the categories A to D. The recommended way to specify in such a case is to indicate first the category of which most requirements are satisfied. The exceptional requirements can then be specified from other categories.

EXAMPLE

"Category C; Abrasion, Humidity: Category B"

3.3 Operating and storage conditions

The temperature specifications in table 1 are meant as storage conditions. For some types of coatings, e.g. bandpass filters and accurate edge filters, it may be necessary that spectral tolerances have to be maintained within a certain temperature range. This should be specified separately, according to the requirements of the application.

3.4 Influence of the substrate

It should be kept in mind, that, in fact, it is not the coating but the entire coating-substrate combination which determines the category of use.

For instance, coatings on glass, normally satisfying category C, might not do so when applied to sensitive or unstable substrate. This is for instance likely to become apparent with the rain, solubility, humidity and salt spray tests.

3.5 Cemented coatings

This part of ISO 9211 does not apply to coatings cemented between two substrate surfaces. The environmental stability of such a substrate-coating-cement-substrate combination depends too much on properties of the cement, as well as the (relative) properties, e.g. thermal expansion, of the two substrate components involved.

4 Specifications

The mechanical and chemical properties of coated optical elements, and more generally their environmental durability, can be assessed by a variety of methods. Test methods selected to give meaningful results representative of actual exposure of optical elements in their operating environment are listed in table 1. The application of any test listed can be limited by the substrate.

The tests in table 1 are subdivided into degrees of severity where appropriate. The severity of the test requirement increases with the number. The description is condensed information about the test method only. The full test procedure shall be taken from appropriate International Standards, referenced in table 1, or can be specified by mutual agreement between customer and manufacturer.

An individual test performed on a one-test-on-one-sample basis can give information about that single property of an optical coating reflected by that test and can be particularly conclusive for the manufacturer. In reality, optical coatings will face a variety of environmental exposures, which can be simulated by certain test sequences. Inevitably, such test sequences represent accumulative requirements. Table 2 lists recommended test sequences for categories A to D. Category O again leaves any option. Requirements without any listed categories in table 1 are to be considered for optional used in category O, and are subject to agreement between supplier and user.

Table 1 — Environmental tests for optical coatings

No.	Test	Degree of severity	Description	Categories of use					Reference[1)]
				A	B	C	D	O	
1	Abrasion	01 02 03 04	50 rub cheesecloth 100 rub cheesecloth 20 rub eraser 40 rub eraser		×	×	×		ISO 9211-4
2	Adhesion	01 02 03	Slow removal Quick removal Snap removal		×	×	×		ISO 9211-4
3	Dust/sand		Expose to the dust-laden air of velocity 8 m/s to 10 m/s, at a temperature of 18 °C to 28 °C and of relative humidity below 25 % for 6 h. The dust concentration is 5 g/m^3 to 15 g/m^3, and the size distribution of dust particle is given in the following table: Dust particle size distribution Size (µm) 140 to 100 100 to 71 71 to 45 <45 % (*m*/*m*) 2 8 15 75 SiO_2 content > 97 %						ISO 9022-6
4	Solubility	01 02 03	Immerse in deionized water at a temperature of 23 °C ± 2 °C for 6 h Immerse in deionized water at a temperature of 23 °C ± 2 °C for 24 h Immerse in salt water (45 g NaCl/l) at a temperature of 23 °C ± 2 °C for 24 h			×	×		ISO 9211-4
5	Damp heat	06 07 03	Expose to an atmosphere of 90 % to 95 % relative humidity and 55 °C ± 2 °C for 6 h Expose to an atmosphere of 90 % to 95 % relative humidity and 55 °C ± 2 °C for 16 h Expose to a temperature of 90 % to 95 % relative humidity and 40 °C ± 2 °C for 10 days		×	×	×		ISO 9022-2
6	Cold	05 07 09	Expose to a temperature of – 25 °C ± 3 °C for 16 h Expose to a temperature of – 35 °C ± 3 °C for 16 h Expose to a temperature of – 55 °C ± 3 °C for 16 h (The temperature change rate should be less than 3 °C/min)	×	×	×	×		ISO 9022-2
7	Dry heat	03 05 06	Expose to an atmosphere of 55 °C ± 2 °C (below 40 % relative humidity) for 16 h Expose to an atmosphere of 70 °C ± 2 °C (below 40 % relative humidity) for 6 h Expose to an atmosphere of 85 °C ± 2 °C (below 40 % relative humidity) for 6 h (The temperature change rate should be less than 5 °C/min)	×	×	×	×		ISO 9022-2

No.	Test	Degree of severity	Description	Categorie of use					Reference[1]
				A	B	C	D	O	
8	Slow temperature change	02 05 07	– 25 °C ± 3 °C to 55 °C ± 2 °C – 35 °C ± 3 °C to 63 °C ± 2 °C – 50 °C ± 3 °C to 70 °C ± 2 °C Test chamber temperature change rate: between 0,2 °C/min and 2 °C/min		×	×	×		ISO 9022-2
9	Salt mist		Expose to salt spray fog of 35 °C ± 2 °C for 24 h Salt solution (concentration: 5 % ± 1 %, pH 6,5 to 7,2) is injected by compressed air ($0,4 \times 10^5$ Pa to $1,7 \times 10^5$ Pa) from 0,5 ml/h to 3,0 ml/h per 80 cm^2 in fallout rate				×		ISO 9022-4[2]
10	Solar radiation	01	Expose to the radiation in a de-ozonised atmosphere of 25 °C ± 2 °C to 55 °C ± 2 °C for 72 h Irradiance on the surface of sample is 1 kW/m^2 ± 0,1 kW/m^2 The radiation source and spectral energy distribution shall be in accordance with table 1 of ISO 9022-9						ISO 9022-9
11	Icing/frosting		Expose to the following atmospheres in succession: Step 1 Initial temperature: – 15 °C ± 3 °C Step 2 Temperature of icing/frosting: – 5 °C ± 2 °C Step 3 Dissolution temperature and humidity: 30 °C ± 2 °C and 80 % to 95 % relative humidity						ISO 9022-14
12	Chemical durability		Immerse in the following agents for respective tests:						ISO 9022-12
12-1	Acid corrosion		1) Sulphric acid (H_2SO_4) 2) Nitric acid (HNO_3)						
12-2	Alkaline corrosion		1) Potassium hydroxide (KOH)						
12-3	Solvent solubility		1) Acetone ($CH_3\ COCH_3$) 2) Ethanol (C_2H_5OH)						
12-4	Boiling water		Deionized water at boiling point The immersion time, the concentration and temperature of the test agents should be specified according to the function and application of the coating intended. (See reference)						

No.	Test	Degree of severity	Description	Categories of use					Reference[1]
				A	B	C	D	O	
13	Mould[3] growth	01	Spray the spore suspension Number of spores in the suspension: 1 000 000/ml ± 200 000/ml Temperature and humidity conditions: 29 °C ± 1 °C, 96 % ± 2 % relative humidity Number of spores on test item surface: 15 000/cm² ± 3 000/cm² Test duration: 28 days Test fungi to be specified						ISO 9022-11
14	[4]								

1) Referenced International Standards are normative test procedures, unless otherwise indicated.

2) Test procedure only; values differ.

3) Mould growth (fungus): the resistance of a coating to damage by mould growth shall be specified, not the prevention of mould growth.

4) Additional durability tests for special applications can be required, such as: rain impact/erosion, sand slurry abrasion, corrosive gases, fluids, etc.

Table 2 — Example of recommended test sequences

Category	Requirements (No.) from table 1							
A	7	6						
B	2	7	6	8	5	1		
C	2	7	6	4	8	5	1	
D	2	7	6	8	5	4	1	9
O								

ICS 37.020.00

Descriptors: optical equipment, surface treatment, coatings, optical coatings, tests, environmental tests, durability.

Price based on 5 pages