
Optics and photonics — Guidance for the selection of environmental tests

*Optiques et photonique — Directives relatives au choix des essais
environnementaux*

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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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 172, *Optics and photonics*, Subcommittee SC 1, *Fundamental standards*.

This document cancels and replaces ISO 10109-1:2005, ISO 10109-6:2005, ISO 10109-7:2001, ISO 10109-8:2005, ISO 10109-11:2001 and ISO 10109-12:2004 which have been technically revised and consolidated into the present standard.

Introduction

Optical and photonic instruments including additional assemblies from other fields (e.g. mechanical, chemical and electronic devices) are affected during their use by a number of different environmental and handling parameters which they are required to resist without significant reduction in performance and to remain within defined specifications. This is what the manufacturer attempts to ensure and the user expects to receive.

This expectation can be assessed by exposure of the instrument to a range of simulated environmental parameters under controlled laboratory conditions. The cumulative combination, degree of severity and sequence of these conditions can be selected to obtain meaningful results in a relatively short period of time.

Technical requirements as given in the tables of this International Standard are abbreviated and the reader has to consult the referenced standards (i.e. the relevant ISO 9022 part) for the full specification of the technical requirement.

For the purposes of ISO 10109, nominal values for properties or performance characteristics are understood to be the manufacturer's internal technical data and do not directly reflect manufacturer's product specifications.

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Optics and photonics — Guidance for the selection of environmental tests

1 Scope

This International Standard contains tables for environmental tests and test parameters which can be used as a guideline for the selection of environmental tests. They include the selection of standardized tests according to ISO 9022 as well as additional parameters not described in ISO 9022 and necessary for the optical or photonic instruments. Ultimately, these tables specify the requirements to be met with regard to the reliability of the optical, mechanical, chemical and electrical properties or performance characteristics of the instruments when exposed to environmental influences.

Environmental test methods, as specified in ISO 9022 (all parts), can be assigned to the various areas of application for the purpose of ascertaining the suitability of the instruments in the respective area of application.

2 Terms and definitions

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

2.1

environmental requirements

specific natural and technical environmental influences, between the limiting values of which optical instruments and instruments with optical, mechanical, chemical and electrical components are to be operable

2.2

technical requirement

defined limiting value for the natural and technical environmental influences occurring in the envisaged area of application

Note 1 to entry: In order to verify whether an instrument fulfils a technical requirement, conditioning methods can be stipulated with degrees of severity whose limiting values are either higher or lower than those specified.

2.3

extent of testing

sum of all required tests to ascertain operability as well as product performance within the intended use and time of life

Note 1 to entry: The extent of design verification/testing is subdivided into:

- design verification and production process controlling (not addressed by this standard),
- testing of functional models, prototypes and production series products.

2.4

severity of testing

number of specimens per production batch/series or sample production to be subjected to a specific test

Note 1 to entry: The severity of testing is stipulated in the relevant specification or in the instrument standard.

2.5

area of application

classification of the operability of an instrument within a defined environment and intended application

EXAMPLE General application in an office environment with air conditioning; or an outdoor application, non-weather protected in arctic climate.

Note 1 to entry: The manufacturer defines the environment parameters. This can be done e.g. by using pre-defined 'standardized areas of application' such as in [Tables 3 to 8](#) in full or in part.

2.6

conditioning method

individual or combined environmental influence(s) to which the specimen is submitted during the test, e.g. shock or damp heat

2.7

degree of severity

parameter containing all the individual quantities required for the test

EXAMPLE Temperature, humidity, conditioning time and others have to be defined for the intended area of application.

Note 1 to entry: See also the specific parts of ISO 9022.

2.8

state of operation

code that designates the state of operation of a specimen

Note 1 to entry: [Table 1](#) gives states of operation in accordance with ISO 9022 (all parts).

Table 1 — States of operation

State of operation	Comment
0	Specimen in its normal transport and/or storage container as provided by the manufacturer (transport container, shipping package).
1	Specimen unprotected, ready for operation, power supply not connected.
2	Specimen is in operation during conditioning for a period to be specified in the relevant specification. The mode of the operating status is specified in the relevant specification. During operation, a check is performed to establish if the specimen is functioning as required.

2.9

status after test

code that designates the outcome of the test as given in [Table 2](#)

Table 2 — Status after test

Status after test	Comment
A	All performance criteria are satisfied.
B	All performance criteria are satisfied. Damage to parts not needed for function or reduced life are possible.
C	Not all performance criteria are satisfied. Damage to parts not needed for function or reduced life are possible.
D	Device may not operate anymore; damage is expected.

3 Environmental influences

3.1 General

Tables 3 to 8 classify and describe standardized environment areas, which constitute a summary of the various environmental parameters with major influences to products during shipping, transport, storage and operation.

The values for standard environments 1 and 2 have been compiled from excerpts of IEC 60721-2-1 and IEC 60721-3-4.

Standard environment 5 is defined for use in weather-protected locations.

Standard environment 6 is defined as an open-air climate with restricted limiting values for optical precision measurements and for the use of optical consumer products in the open air.

3.2 Standard environment 1

**Table 3 — Non-weather-protected locations with cold or extremely cold climates
(Arctic or Antarctic climate)**

Environmental influence	Value	Comment
Temperature	–65 °C to +35 °C	In extreme geographical conditions, temperatures as low as –75 °C and as high as 40 °C can occur in the location of use. With temporary or permanent storage in enclosed vehicles, sheds, hangars or attics, temperatures of over 35 °C can be experienced in strong sunshine, and over 70 °C in extreme cases.
Relative humidity	up to 100 %	At a relative humidity of ≥ 95 %, the maximum temperature occurring is 20 °C.
Air pressure	70 kPa to 106 kPa	50 kPa to 110 kPa in unfavourable conditions.
Solar radiation	up to 1,1 kW/m ²	Intensity of global radiation on earth's surface.
Amount of precipitation (rain, snow or hail)	≤ 15 mm/min	
Dew or ice build-up	yes	

3.3 Standard environment 2

**Table 4 — Global locations, non-weather-protected,
with the exception of cold and extremely cold climates**

Environmental influence	Value	Comment
Temperature	–33 °C to +55 °C	In extreme geographical conditions, temperatures as low as –45 °C and over 60 °C can be experienced in the location of use. With temporary or permanent storage in enclosed vehicles, sheds, hangars or attics, temperatures of over 55 °C can occur in strong sunshine, and over 85 °C in extreme cases.
Relative humidity	up to 100 %	At a relative humidity of ≥ 95 %, the highest temperature occurring is 33 °C, and 37 °C in extreme conditions.
Air pressure	70 kPa to 106 kPa	50 kPa to 110 kPa in unfavourable conditions.
Solar radiation	up to 1,1 kW/m ²	Intensity of global radiation on earth's surface.
Amount of precipitation (rain, snow or hail)	≤ 15 mm/min	
Dew or ice build-up	yes	

3.4 Standard environment 3

Table 5 — Global locations, non-weather-protected, with maritime and/or coastal climate

Environmental influence	Value	Comment
Temperature	–20 °C to +35 °C	Along coasts with icing, temperatures below –20 °C can be experienced, and above 35 °C along tropical coasts. With temporary or permanent storage in enclosed vehicles, sheds, hangars or attics, temperatures over 35 °C can be experienced in strong sunshine, and over 85 °C in extreme cases.
Relative humidity	up to 100 %	At a relative humidity of ≥ 95 %, the highest temperature occurring is 30 °C.
Air pressure	90 kPa to 106 kPa	50 kPa to 110 kPa in unfavourable conditions.
Solar radiation	up to 1,1 kW/m ²	Intensity of global radiation on earth's surface
Amount of precipitation (rain, snow or hail)	≤ 15 mm/min	
Dew or ice build-up	yes	

3.5 Standard environment 4

Table 6 — High altitudes of up to 30 000 m

Environmental influence	Value	Comment
Temperature	–65 °C to +55 °C	Above polar zones, temperatures below –65 °C have to be expected. With temporary or permanent storage in enclosed vehicles, sheds, hangars or attics, temperatures over 55 °C can be experienced in strong sunshine, and over 85 °C in extreme cases.
Relative humidity	up to 100 %	At a relative humidity of ≥ 95 %, the highest temperature occurring is 35 °C.
Air pressure	1 kPa to 106 kPa	
Solar radiation	up to 1,4 kW/m ²	Intensity of radiation at altitude of 30 000 m.
Amount of precipitation (rain, snow or hail)	≤ 15 mm/min	
Dew or ice build-up	yes	

3.6 Standard environment 5

Table 7 — Technical climate in weather-protected locations

Environmental influence	Value	Comment
Temperature	+15 °C to +35 °C	In unfavourable conditions, temperatures below 15 °C and over 35 °C may occur.
Relative humidity	up to 85 %	In unfavourable conditions, relative humidities of up to 95 % can be experienced.
Air pressure	70 kPa to 106 kPa	50 kPa to 110 kPa in unfavourable conditions.
Solar radiation	up to 0,9 kW/m ²	Without protection from sunshine.

3.7 Standard environment 6

Table 8 — Non-weather-protected locations with restricted limiting values

Environmental influence	Value	Comment
Temperature	–20 °C to +50 °C	The restricted temperature range applies for state of operation 2. The values of Standard environment 2 apply for the states of operation 0 and 1.
Relative humidity	up to 100 %	At a relative humidity of ≥ 95 %, the highest temperature occurring is 25 °C.
Air pressure	70 kPa to 106 kPa	50 kPa to 110 kPa in unfavourable conditions.
Solar radiation	up to 1,1 kW/m ²	With simultaneous high exposure to heat and solar radiation, the critical limiting values for temperature in and on the instrument shall not be exceeded.
Amount of precipitation (rain, snow or hail)	≤ 6 mm/min	
Dew or ice build-up	yes	

4 Table for environmental tests and test parameters

The wide range of technologies applied in complex instruments often requires specific and individually selected test parameters, test sequences and combined tests. [Table 9](#) is a collection of mainly climatic and mechanical tests.

The user of this International Standard, e.g. a manufacturer, selects the tests and adapts the parameters to his specific equipment. A specific area of application has to be defined for every item of equipment and both the tests and the degree of severity also have to be adapted to the intended climatic and operating environment and to the customer expectations. It is up to the manufacturer to carefully select the appropriate tests, the combination of the tests, the required technical parameters, the degree of severity, the status of operation and other parameters. An example is given in [Annex A](#).

As a general test result, the status after the test can be shown in the table for each specific test-run.

Note that in [Table 9](#), the combination of the three columns “Conditioning method”, “Degree of severity” and “State of operation” provide the full specification using the coded format as defined in ISO 9022-1. The column labelled “Technical requirement” is only a short description and does not reproduce the full requirement. For a full description, it is necessary to consult the referenced standards.

Table 9 — List of international environmental and handling tests for optical and photonics equipment (the tests may be selected and combined as required)

Test number	Test description	In accordance with standard (leave blank if no accordance)	Conditioning method	Area of application: (e.g. Outdoor)			
				Description of application:			
				Degree of severity	State of operation	Technical requirement	Status after test
1	Climate					Select the test and fill in the required parameters	
1.1	Cold	ISO 9022-2	10				
1.2	Heat (dry heat)	ISO 9022-2	11				

Table 9 (continued)

Test number	Test description	In accordance with standard (leave blank if no accordance)	Conditioning method	Area of application: (e.g. Outdoor)			
				Description of application:			
				Degree of severity	State of operation	Technical requirement	Status after test
1.3	Damp heat, (rarely and slightly condensing)	ISO 9022-2	12				
1.4	Condensed water	ISO 9022-2	13				
1.5	Slow temperature change	ISO 9022-2	14				
1.6	Temperature shock, rapid temperature change	ISO 9022-2	15				
1.7	Damp heat, cyclic	ISO 9022-2	16				
1.8	Cold, dry heat or temperature change with bump or random vibration	ISO 9022-22	22				
2	Atmosphere					Select the test and fill in the required parameters	
2.1	Combined low pressure and ambient temperature	ISO 9022-23	45				
2.2	Combined low pressure and dry heat	ISO 9022-23	46				
2.3	Damp heat and low internal pressure, pressure difference low	ISO 9022-23	47				
2.4	Damp heat and low internal pressure, pressure difference medium	ISO 9022-23	48				
2.5	Damp heat and low internal pressure, pressure difference height	ISO 9022-23	49				
2.6	Combined cold, low air pressure including hoar-frost and dew	ISO 9022-23	50				
2.7	Combined cold, low air pressure without hoar-frost and dew	ISO 9022-23	51				
2.8	Excess pressure						
2.9	Subatmospheric pressure	ISO 9022-23	51				
2.10	High internal pressure	ISO 9022-8	80				

Table 9 (continued)

Test number	Test description	In accordance with standard (leave blank if no accordance)	Conditioning method	Area of application: (e.g. Outdoor)			
				Description of application:			
				Degree of severity	State of operation	Technical requirement	Status after test
2.11	Low internal pressure	ISO 9022-8	81				
2.12	Immersion	ISO 9022-8	82				
2.13	Dust	ISO 9022-6	52				
2.14	Drip	ISO 9022-7	72				
2.15	Steady rain	ISO 9022-7	73				
2.16	Driving rain	ISO 9022-7	74				
2.17	Dew	ISO 9022-14	75				
2.18	Hoarfrost, followed by process of thawing	ISO 9022-14	76				
2.19	Ice covering, followed by process of thawing	ISO 9022-14	77				
2.20	Precipitation:						
	- Rain	IEC 60529					
	- Snow	IEC 60529					
	- Hail	IEC 60529					
	- Fog	IEC 60529					
	- Freezing fog	IEC 60529					
	- Hoarfrost	IEC 60529					
2.21	Icing						
2.22	Solar radiation	ISO 9022-9	20				
2.23	One-sided sun exposure						
2.24	Wind						
2.25	Dust	IEC 60529					
2.26	Sand						
2.27	Polluted atmosphere - salt	IEC 60068-2-11					
2.28	Polluted atmosphere - marine environment	IEC 60068-2-52					
2.29	Polluted atmosphere - H ₂ S	IEC 60068-2-43					
2.30	Polluted atmosphere - SO ₂	IEC 60068-2-42					
2.31	Polluted atmosphere - NH ₃						
2.32	Polluted atmosphere - Ozone						
							

Table 9 (continued)

Test number	Test description	In accordance with standard (leave blank if no accordance)	Conditioning method	Area of application: (e.g. Outdoor)			
				Description of application:			
				Degree of severity	State of operation	Technical requirement	Status after test
3	Mechanical					Select the test and fill in the required parameters	
3.1	Shock	ISO 9022-3	30				
3.2	Handling shock	ISO 9022-3	30/33				
3.3	Bump	ISO 9022-3	31				
3.4	Drop and topple	ISO 9022-3	32				
3.5	Drop in transportation case	ISO 9022-3	33				
3.6	Drop in package for shipping	ISO 9022-3	33				
3.7	Free fall	ISO 9022-3	33				
3.8	Bounce	ISO 9022-3	34				
3.9	Steady-state acceleration, centrifugal	ISO 9022-3	35				
3.10	Sinusoidal vibration	ISO 9022-3	36				
3.11	Vibration in transportation case	ISO 9022-3	36/37				
3.12	Random vibration (wide-band) digitally controlled	ISO 9022-3	37				
....							
4	Chemical					Select the test and fill in the required parameters	
4.1	Salt mist	ISO 9022-4	40				
4.2	Humid atmosphere containing sulfur dioxide (SO ₂)	ISO 9022-20	41				
4.3	Humid atmosphere containing hydrogen sulfide (H ₂ S)	ISO 9022-20	42				
4.4	Mould growth	ISO 9022-11	85				
4.5	Contamination: Basic cosmetic substances and artificial hand sweat	ISO 9022-12	86				
4.6	Contamination: Laboratory agents	ISO 9022-12	87				
4.7	Contamination: Production plant resources	ISO 9022-12	88				

Table 9 (continued)

Test number	Test description	In accordance with standard (leave blank if no accordance)	Conditioning method	Area of application: (e.g. Outdoor)			
				Description of application:			
				Degree of severity	State of operation	Technical requirement	Status after test
4.8	Contamination: Fuels and resources for aircraft, naval vessels and vehicles	ISO 9022-12	89				
							
5	Optional tests					individual technical requirements	

Annex A (informative)

Example of selection of environmental tests

As an example, an area of application has been defined in [Table A.1](#) for a typical “Outdoor use”. If necessary more “Area of application” columns can be added.

The combination of the three columns “Conditioning method”, “Degree of severity” and “State of operation” provide the full specification using the coded format as defined in ISO 9022-1. The column labelled “Technical requirement” is only a short description and does not reproduce the full requirement. For a full description, it is necessary to consult the referenced standards.

Table A.1 — Example of selection of environmental tests for an outdoor application in non-weather-protected locations and/or temperature zones

Test number	Test description	In accordance with standard	Conditioning method	Area of application: Outdoor			
				Non-weather-protected locations, temperate zones			
				Degree of severity	State of operation	Technical requirement	Status after test
1	Climate					Select the tests and fill in the required parameters	
1.1	Cold	ISO 9022-2	10	04	2	–20 °C / 16 h	A
1.2	Heat (dry heat)	ISO 9022-2	11	03	0,1	+55 °C	A
1.3	Damp heat, (rarely and slightly condensing)	ISO 9022-2	12	06	2	+50 °C, avg./year r.h. 75 %; max. 95 %	C
1.4	Condensed water	ISO 9022-2	13	03	1	2d, +40°C, 100 % rel. humidity	C
1.5	Slow temperature change	ISO 9022-2	14	02	0,1	from +55 °C to –20 °C	A
1.6	Temperature shock, rapid temperature change	ISO 9022-2	15	02	0,1	from +40 °C to –25 °C	A
1.7	Damp heat, cyclic	ISO 9022-2	16	04	2	+23 °C / 83 % to 55 °C / 95 %	A
1.8	Cold, dry heat or temperature change with bump or random vibration	ISO 9022-22	22		2	Dry heat, 55 °C (ISO 9022-11-03) Vibration 20 Hz to 150 Hz, 0,02 g _n ² /Hz (ISO 9022-37-01)	A
2	Atmosphere					Select the tests and fill in the required parameters	
2.1	Combined low pressure and ambient temperature	ISO 9022-23	45	01	2	23 °C, 800 hPa	A

Table A.1 (continued)

Test number	Test description	In accordance with standard	Conditioning method	Area of application: Outdoor			
				Non-weather-protected locations, temperate zones			
				Degree of severity	State of operation	Technical requirement	Status after test
2.2	Combined low pressure and dry heat	ISO 9022-23	46	03	2	55 °C, 100 hPa, exposure 24 h	A
2.3	Damp heat and low internal pressure, pressure difference low	ISO 9022-23	47	02	2	55 °C, < 40 % r.h., 12 cycles, etc.	A
2.4	Damp heat and low internal pressure, pressure difference medium	ISO 9022-23	48	02	2	40 °C, 800 hPa, 90 % r.h., Cond.2: -10 °C, Cond.3: 40 °C	A
2.5	Damp heat and low internal pressure, pressure difference height	ISO 9022-23	49	02	2	40 °C, 90 % r.h., etc.	A
2.6	Combined cold, low air pressure including hoarfrost and dew	ISO 9022-23	50	02	1	-40 °C, 60 kPa, 4 h	A
2.7	Combined cold, low air pressure without hoarfrost and dew	ISO 9022-23	51	02	1	-40 °C, 60 kPa, 4 h	A
2.8	Excess pressure				0,2	-1000 m NOTE Only if used in mines (with or without firedamp).	A
2.9	Subatmospheric pressure	ISO 9022-23	51	01	0,2	altitude up to 8500 m	A
2.10	High internal pressure	ISO 9022-8	80	03	2	40 °C, press diff: 100 hPa, drop: 20 hPa, exposure 10 min	A
2.11	Low internal pressure	ISO 9022-8	81	03	2	40 °C, press diff: 100 hPa, rise: 20 hPa, exposure 10 min	
2.12	Immersion	ISO 9022-8	82	02	2	immersion depths, 4 m, exposure 2 h	A
2.13	Dust	ISO 9022-6	52	02	1	18 °C to 28 °C, < 25 % r.h., 8 m/s to 10 m/s	A
2.14	Drip	ISO 9022-7	72	04	1	Drip rate: 3,5 mm/min, exposure: 5 min	A
2.15	Steady rain	ISO 9022-7	73	02	1	Rain rate: 20 mm/min, exposure: 30 min	A
2.16	Driving rain	ISO 9022-7	74	04	1	Rain rate: 10 mm/sec, wind 18 m/s, exposure: 30 min	A