INTERNATIONAL STANDARD

ISO 9022-3

Second edition
1998-07-15

Optics and optical instruments — Environmental test methods —

Part 3:
Mechanical stress

Optique et instruments d'optique — Méthodes d'essais d'environnement —

Partie 3: Contraintes mécaniques

Reference number
ISO 9022-3:1998(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 9022-3 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 1, *Fundamental standards.*

This second edition cancels and replaces the first edition (ISO 9022-3:1994), which has been technically revised.

ISO 9022 consists of the following parts, under the general title *Optics and optical instruments — Environmental test methods*:

— *Part 1: Definitions, extent of testing*

— *Part 2: Cold, heat, humidity*

— *Part 3: Mechanical stress*

— *Part 4: Salt mist*

— *Part 5: Combined cold, low air pressure*

— *Part 6: Dust*

— *Part 7: Drip, rain*

— *Part 8: High pressure, low pressure, immersion*

International Organization for Standardization
Case postale 56 • CH-1211 Genève 20 • Switzerland
Internet iso@iso.ch

Printed in Switzerland

— *Part 9: Solar radiation*
— *Part 10: Combined sinusoidal vibration and dry heat or cold*
— *Part 11: Mould growth*
— *Part 12: Contamination*
— *Part 13: Combined shock, bump or free fall and dry heat or cold*
— *Part 14: Dew, hoarfrost, ice*
— *Part 15: Combined digitally controlled broad-band random vibration and dry heat or cold*
— *Part 16: Combined bounce or steady-state acceleration and dry heat or cold*
— *Part 17: Combined contamination, solar radiation*
— *Part 18: Combined damp heat and low internal pressure*
— *Part 19: Temperature cycles combined with sinusoidal or random vibration*
— *Part 20: Humid atmosphere containing sulfur dioxide or hydrogen sulfide*
— *Part 21: Combined low pressure and ambient temperature or dry heat*

Introduction

Optical instruments are affected during their use by a number of different environmental parameters which they are required to resist without significant reduction in performance.

The type and severity of these parameters depend on the conditions of use of the instrument (for example, in the laboratory or workshop) and on its geographical location. The environmental effects on optical instrument performance in the tropics and subtropics are totally different from those found when they are used in arctic regions. Individual parameters cause a variety of different and overlapping effects on instrument performance.

The manufacturer attempts to ensure, and the user naturally expects, that instruments will resist the likely rigours of their environment throughout their life. This expectation can be assessed by exposure of the instrument to a range of simulated environmental parameters under controlled laboratory conditions. The severity of these conditions is often increased to obtain meaningful results in a relatively short period of time.

In order to allow assessment and comparison of the response of optical instruments to appropriate environmental conditions, ISO 9022 contains details of a number of laboratory tests which reliably simulate a variety of different environments. The tests are based largely on IEC standards, modified where necessary to take into account features special to optical instruments.

It should be noted that, as a result of continuous progress in all fields, optical instruments are no longer only precision-engineered optical products, but, depending on their range of application, also contain additional assemblies from other fields. For this reason, the principal function of the instrument must be assessed to determine which International Standard should be used for testing. If the optical function is of primary importance, then ISO 9022 is applicable, but if other functions take precedence then the appropriate International Standard in the field concerned should be applied. Cases may arise where application of both ISO 9022 and other appropriate International Standards will be necessary.

Optics and optical instruments — Environmental test methods —

Part 3:
Mechanical stress

1 Scope

This part of ISO 9022 specifies methods for the testing of optical instruments and instruments containing optical components, under equivalent conditions, for their ability to resist mechanical stress.

The purpose of the testing is to investigate to what extent the optical, thermal, mechanical, chemical and electrical performance characteristics of the specimen are affected by mechanical stress.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 9022. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 9022 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 9022-1:1994, *Optics and optical instruments — Environmental test methods — Part 1: Definitions, extent of testing.*

IEC 60068-2-6:1995, *Environmental testing — Part 2: Tests — Test Fc: Vibration (sinusoidal).*

IEC 60068-2-7:1983, *Environmental testing — Part 2: Tests — Test Ga and guidance: Acceleration, steady state.*

IEC 60068-2-27:1987, *Environmental testing — Part 2: Tests — Test Ea and guidance: Shock*.

IEC 60068-2-29:1987, *Environmental testing — Part 2: Tests — Test Eb and guidance: Bump*.

IEC 60068-2-31:1969, *Environmental testing — Part 2: Tests — Test Ec: Drop and topple, primarily for equipment-type specimens*.

IEC 60068-2-32:1975, *Environmental testing — Part 2: Tests — Test Ed: Free fall*.

IEC 60068-2-47:1982, *Environmental testing — Part 2: Tests — Mounting of components, equipment and other articles for dynamic tests including shock (Ea), bump (Eb), vibration (Fc and Fd) and steady-state acceleration (Ga) and guidance*.

IEC 60068-2-55:1987, *Environmental testing — Part 2: Tests — Test Ee and guidance: Bounce*.

IEC 60068-2-64:1993, *Environmental testing — Part 2: Test methods — Test Fh: vibration, broad-band random (digital control) and guidance*.

3 General information and test conditions

The test shall be carried out at ambient atmospheric conditions and in accordance with ISO 9022-1 and with the International Standards listed in table 1. The specimens shall be mounted on the test apparatus (shock machine, acceleration facility, or electrodynamic shaker) in accordance with IEC 60068-2-47.

"g_n" is the standard acceleration due to the earth's gravity, which itself varies with altitude and geographical latitude.

NOTE For the purposes of this part of ISO 9022, the value of g_n is rounded up to the nearest whole number, that is 10 m/s^2.

Table 1 — Conditioning methods and applicable International Standards for testing

Subclause	Conditioning methods	International Standard
4.1	30: Shock	IEC 60068-2-27
4.2	31: Bump	IEC 60068-2-29
4.3	32: Drop and topple	IEC 60068-2-31
4.4	33: Free fall	IEC 60068-2-32
4.5	34: Bounce	IEC 60068-2-55
4.6	35: Steady-state acceleration	IEC 60068-2-7
4.7	36: Sinusoidal vibration	IEC 60068-2-6
4.8	37: Random vibration (wide-band), digital control	IEC 60068-2-64

4 Conditioning

4.1 Conditioning method 30: Shock

See table 2.

When testing optical instruments, a half-sine shock pulse shall be applied. The specimen shall be subjected to three shocks in each direction along each axis.

Table 2 — Degrees of severity for conditioning method 30: Shock

Degree of severity		01	**02**	**03**	04	**05**	06	07	08[1)]
Acceleration amplitude	m ·s^{-2}	100	150	300	300	500	500	1 000	5 000
	g_n multiples	10	15	30	30	50	50	100	500
Duration of nominal shock	ms	6	11	6	18	3	11	6	1
State of operation		0 or 1 or 2							
NOTE Degrees of severity in boldface shall be given preference.									
1) Applicable to testing of components and assemblies. Complete optical instruments should be subjected to 500 g acceleration and shocks of 0,5 ms duration.									

4.2 Conditioning method 31: Bump

See table 3.

Table 3 — Degrees of severity for conditioning method 31: Bump

Degree of severity		01	02	03	04	05	06	07	08
Acceleration amplitude	m ·s^{-2}	100	100	100	100	250	250	400	400
	g_n multiples	10	10	10	10	25	25	40	40
Duration of nominal shock	ms	6	6	16	16	6	6	6	6
Number of shocks in each direction along each axis ± 10		1 000	4 000	1 000	4 000	1 000	4 000	1 000	4 000
State of operation		0 or 1 or 2							

4.3 Conditioning method 32: Drop and topple

See table 4.

Table 4 — Degrees of severity for conditioning method 32: Drop and topple

Degree of severity		01[1)]	02[1)]	03[1)]	04[2)]
Height of overturn	mm	25	50	100	Toppling over
	Acceptable deviation mm	± 5			—
State of operation		0 or 1			

1) The specimen shall be subjected to one drop on each of four bottom corners and along each of four bottom edges.

2) The specimen shall be subjected to one topple about each of four bottom edges.

4.4 Conditioning method 33: Free fall

See table 5.

Table 5 — Degrees of severity for conditioning method 33: Free fall

Degree of severity		01	02	03	04	05	06
Height of fall	mm	25	50	100	250	500	1000
	Acceptable deviation mm	± 5			± 10		
State of operation		0 or 1					
Mass of specimen including packing[1)]	kg	> 500	⩽ 500	⩽ 200	⩽ 100	⩽ 50	⩽ 20

NOTE Storage containers shall not be considered as packing.

1) Recommendation for selection of degrees of severity.

Unpackaged optical instruments shall not be tested unless they are specially designed, constructed and armoured (e.g. rubber armouring) for free fall. The degrees of severity are applicable to normal transport handling. Unless otherwise prescibed in the relevant specification, the specimen shall be subjected to two falls. If another number of falls is taken, the total number of falls shall be preferably taken from the following series: 10; 20; 50.

4.5 Conditioning method 34: Bounce

See table 6.

The test shall be carried out according to IEC 60068-2-55 on a bounce table with a double amplitude of 25,5 mm ± 0,5 mm and a frequency of 4,75 Hz ± 0,05 Hz.

Table 6 — Degrees of severity for conditioning method 34: Bounce

Degree of severity		01	**02**	03
Exposure time	min	15	60	180
	Acceptable deviation	± 10 %		
State of operation		0 or 1		
NOTE The degree of severity printed in boldface shall be given preference. The period of exposure shall be allocated in equal portions to each of the surfaces to be exposed.				

4.6 Conditioning method 35: Steady-state acceleration, centrifugal

See table 7.

Table 7 — Degrees of severity for conditioning method 35: Steady-state acceleration, centrifugal

Degree of severity		01	02	03	04	05	06
Acceleration	$m \cdot s^{-2}$	50	100	200	500	1000	2000
	g_n multiples	5	10	20	50	100	200
Exposure time along each axis and in each direction	s	>10*)					
State of operation		0 or 1 or 2					
*) The exposure time begins after reaching the rated number of revolutions.							

4.7 Conditioning method 36: Sinusoidal vibration

4.7.1 General

The degrees of severity specified in table 8 are relevant to optical instruments because the low frequencies combined with large displacement amplitudes do not stress optical instruments.

In special cases refer to table 4 or figure 1 of IEC 60068-2-6:1995.

4.7.2 Vibration testing using sweep frequencies

See tables 8 and 9.

Table 8 — Degrees of severity for conditioning method 36: Sinusoidal vibration using sweep frequencies

Degree of severity		01	02	03	04	05	06	07	08	09	10
Displacement	mm	0,035	0,075	0,15	0,15	0,15	0,15	0,35	0,35	0,35	1,0
Acceleration	$m \cdot s^{-2}$	5	10	20	20	—	20	50	50	50	—
	g_n multiples	0,5	1	2	2	—	2	5	5	5	—
Number of frequency cycles[1] to be used on each axis per frequency band	10 Hz to 55 Hz	—	—	—	—	5	—	—	—	—	20
	10 Hz to 150 Hz	—	—	20	—	—	—	5	—	—	—
	10 Hz to 500 Hz	2	—	—	10	—	—	—	10	—	—
	10 Hz to 2000 Hz	—	2	—	—	—	10	—	—	10	—
State of operation		0 or 1 or 2									
1) The sweep rate for the specified number of frequency cycles shall be 1 octave per minute.											

Table 9 — Typical applications

Frequency band Hz	Examples of application
10 to 55	Instruments installed in ships and other naval craft or in the neighbourhood of heavy rotating machines and for general industrial requirements.
10 to 150	Instruments for general industrial requirements and for use in and transport on ground vehicles.
10 to 500	Equipment for general airborne use and for use in ground vehicles (e.g. tracked vehicles) under special conditions.
10 to 2000	Equipment for use in high-speed aircraft and missiles and in special vehicles such as hovercraft.

4.7.3 Vibration fatigue test using characteristic frequencies

See table 10.

The vibration fatigue test, using characteristic frequencies, shall not be performed unless in combination with the condition specified in 4.7.2.

The specimen shall be vibrated along each axis for the time specified in table 10. If the characteristic frequencies depend on the location of the specimen, they shall be specified in the relevant specification. In the event that more than one characteristic frequency is used, portions of the exposure time shall be allocated to each frequency. The portion of exposure time to be allocated to each characteristic frequency shall be specified in the relevant specification.

Table 10 — Duration of the vibration fatigue test using characteristic frequencies

Acceleration or displacement		To be selected from table 8		
Exposure time using characteristic frequencies	min	10	30	90
	Acceptable deviation	± 10 %		

4.8 Conditioning method 37: Random vibration (wide-band) digitally controlled

The total conditioning time which is specified in tables 11 to 13 shall be devided equally between the conditioning axes defined in the relevant specification.

Table 11 — Degrees of severity for conditioning method 37: Random vibration; frequency range from 20 Hz to 150 Hz

Degree of severity		01	02	03	04
Acceleration power spectral density	g_n^2 /Hz	0,02	0,05	0,2	0,2
Rms acceleration[1)]	(g multiples)	1,6	2,6	5,1	5,1
Frequency range (f_1 to f_2)	Hz	20 to 150			
Conditioning time along each axis	min	10	10	10	30
	Acceptable deviation	± 10 %			
State of operation		0 or 1 or 2			

1) The values refer to a rectangular spectrum.

Table 12 — Degrees of severity for conditioning method 37: Random vibration; frequency range from 20 Hz to 500 Hz

Degree of severity		11	12	13	14	15
Acceleration power spectral density	g_n^2/Hz	0,005	0,01	0,05	0,05	0,05
Rms acceleration[1)]	(g multiples)	1,6	2,2	4,9	4,9	4,9
Frequency range (f_1 to f_2)	Hz	20 to 500				
Conditioning time along each axis	min	10	10	10	30	90
	Acceptable deviation	± 10 %				
State of operation		0 or 1 or 2				

1) The values refer to a rectangular spectrum.

Table 13 — Degrees of severity for conditioning method 37: Random vibration; frequency range from 20 Hz to 2 000 Hz

Degree of severity		21	22	23	24	25[1)]	26[1)]
Acceleration power spectral density	g_n^2/Hz	0,001	0,01	0,01	0,05	0,02	0,05
Rms acceleration[2)]	(g multiples)	1,4	4,5	4,5	10	6,3	10
Frequency range (f_1 to f_2)	Hz	20 to 2 000					
Conditioning time along each axis	min	10	10	30	30	90	90
	Acceptable deviation	± 10 %					
State of operation		0 or 1 or 2					

1) For missiles and jet aircraft.
2) The values refer to a rectangular spectrum.

5 Procedure

The tests shall be conducted in accordance with the requirements of the relevant specification and with ISO 9022-1 and the relevant parts of IEC 60068 listed in clause 2.

6 Environmental test code

The environmental test code shall be as defined in ISO 9022-1, giving a reference to ISO 9022 and the codes for the conditioning method chosen, the degree of severity and the state of operation.

EXAMPLE

The environmental test of optical instruments for resistance to shock, conditioning method 30, degree of severity 01, and state of operation 1 is identified as:

Environmental test ISO 9022-30-01-1

7 Specification

The relevant specification shall contain the following details:

a) environmental test code;

b) number of specimens;

c) data as required by the International Standards listed in table 1 (the requirements of ISO 9022-3 shall prevail);

d) conditioning methods 30 and 31: axes and directions of exposure;

e) conditioning method 32: edge over which to tilt and number of conditionings;

f) conditioning method 33: condition of package prior to and after conditioning, number of conditionings, and number of the edges, corners and surfaces to be exposed;

g) conditioning method 34: surface to be exposed;

h) conditioning method 35: axes along which, and directions in which, specimens are to be exposed;

i) conditioning methods 36 and 37: axes along which to expose specimens;

j) conditioning method 36 (4.7.3): portion of exposure time to be allocated to each characteristic frequency; characteristic frequency at the installed position of the specimen, where appropriate;

k) preconditioning;

l) type and scope of initial test;

m) period of operation for state of operation 2;

n) type and scope of intermediate test for state of operation 2;

o) recovery;

p) type and scope of final test;

q) criteria for evaluation;

r) type and scope of test report.

ICS 37.020

Descriptors: optics, optical equipment, tests, environmental tests, mechanical tests, determination, stresses.

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