INTERNATIONAL STANDARD

# ISO 9022-3

First edition
1994-07-15

# 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 9022-3:1994(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 9022-3 was prepared by Technical Committee ISO/TC 172, *Optics and optical instruments*, Subcommittee SC 1, *Fundamental standards*.



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*
- *Part 9: Solar radiation*
- *Part 10: Combined sinusoidal vibration, dry heat or cold*



International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

— *Part 11: Mould growth*

— *Part 12: Contamination*

— *Part 13: Combined shock, bump or free fall, dry heat or cold*

— *Part 14: Dew, hoarfrost, ice*

— *Part 15: Combined random vibration wide band: reproducibility medium, in dry heat or cold*

— *Part 16: Combined bounce or steady-state acceleration, in 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*

## 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 the 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 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[1)], *Optics and optical instruments — Environmental test methods — Part 1: Definitions, extent of testing.*

IEC 68-2-6:1985, *Environmental testing — Part 2: Tests — Test Fc and guidance: Vibration (sinusoidal).*

IEC 68-2-7:1983, *Environmental testing — Part 2: Tests — Test Ga and guidance: Acceleration, steady state.*

IEC 68-2-27:1987, *Environmental testing — Part 2: Tests — Test Ea and guidance: Shock.*

IEC 68-2-29:1987, *Environmental testing — Part 2: Tests — Test Eb and guidance: Bump.*

IEC 68-2-31:1969, *Environmental testing — Part 2: Tests — Test Ec: Drop and topple, primarily for equipment-type specimens.*

IEC 68-2-32:1975, *Environmental testing — Part 2: Tests — Test Ed: Free fall.*

IEC 68-2-34:1973, *Environmental testing — Part 2: Tests — Test Fd: Random vibration wide band — General requirements.*

IEC 68-2-36:1973, *Environmental testing — Part 2: Tests — Test Fdb: Random vibration wide band — Reproducibility medium.*

IEC 68-2-47:1982, *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 68-2-55:1987, *Environmental testing — Part 2: Tests — Test Ee and guidance: Bounce.*

1) To be published.

## 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 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 68-2-47.

For the purposes of this International Standard, the acceleration of free fall shall be taken as $g = 9{,}81\ \mathrm{m{\cdot}s^{2}}$.

**Table 1 — Conditioning methods and applicable standards for testing**

| Subclause | Conditioning methods | Standards |
|---|---|---|
| 4.1 | 30: Shock | IEC 68-2-27 |
| 4.2 | 31: Bump | IEC 68-2-29 and amendment No. 1 |
| 4.3 | 32: Drop and topple | IEC 68-2-31 and amendment No. 1 |
| 4.4 | 33: Free fall | IEC 68-2-32 and amendment No. 1 |
| 4.5 | 34: Bounce | IEC 68-2-55 |
| 4.6 | 35: Steady-state acceleration | IEC 68-2-7 |
| 4.7 | 36: Sinusoidal vibration | IEC 68-2-6 and amendments No. 1 and No. 2 |
| 4.8 | 37: Random vibration (wide band), reproducibility: medium | IEC 68-2-34 and amendment No. 1 IEC 68-2-36 and amendment No.1 |

## 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.

### 4.2 Conditioning method 31: Bump

See table 3.



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

| Degree of severity | | 01 | **02** | **03** | 04 | **05** | 06 | 07 | 08 1) |
|---|---|---|---|---|---|---|---|---|---|
| Acceleration amplitude | $\mathrm{m{\cdot}s^{-2}}$ | 98 | 147 | 294 | 294 | 490 | 490 | 981 | 4 900 |
| | $g$ 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.

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

| Degree of severity | | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 |
|---|---|---|---|---|---|---|---|---|---|
| Acceleration amplitude | $\mathrm{m{\cdot}s^{-2}}$ | 98 | 98 | 98 | 98 | 245 | 245 | 392 | 392 |
| | $g$ 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 | ± 1 % | 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.

## 4.4 Conditioning method 33: Free fall

See table 5.

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 prescribed 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 prescribed in the relevant specification and 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 68-2-55 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 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 | $^{+20}_{0}$ % | | | — |
| ***State of operation*** | | 0 or 1 or 2 | | | |

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.



**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 | 1 000 |
| | Acceptable deviation | $^{+20}_{0}$ % | | | | | |
| **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.

**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.

## 4.7 Conditioning method 36: Sinusoidal vibration

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 68-2-6.

### 4.7.1 Vibration testing using sweep frequencies

See tables 8 and 9.

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

| Degree of severity | | **01** | 02 | 03 |
|---|---|---|---|---|
| Acceleration | $m \cdot s^{-2}$ | **49** | 98 | 196 |
| | $g$ multiples | **5** | 10 | 20 |
| Exposure time along each axis and in each direction | min | 1 to 2 | | |
| State of operation | | 1 or 2 | | |

NOTE — The degree of severity printed in boldface shall be given preference.



**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 | $m \cdot s^{-2}$ | 4,9 | 9,8 | 19,6 | 19,6 | — | 19,6 | 49 | 49 | 49 | — |
| | $g$ 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 2 000 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 2 000 | Equipment for use in high-speed aircraft and missiles and in special vehicles such as hovercraft. |

#### 4.7.2 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 4.7.1.

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.

### 4.8 Conditioning method 37: Random vibration (wide band), reproducibility: medium

The total conditioning time which is specified in tables 11 to 13 shall be divided equally between the conditioning axes defined 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 % | | |

**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** | $g^2$/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 | | | |
| **Total conditioning time** | min | 9 | 9 | 9 | 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** | $g^2$/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 | | | | |
| **Total conditioning time** | min | 9 | 9 | 9 | 30 | 90 |
| | Acceptable deviation | ± 10 % | | | | |
| **State of operation** | | 0 or 1 or 2 | | | | |

1) The values refer to a rectangular spectrum.