# INTERNATIONAL STANDARD

**ISO 4180**

First edition
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# Packaging — Complete, filled transport packages — General rules for the compilation of performance test schedules

*Emballages — Emballages d'expédition complets et pleins — Règles générales pour l'établissement de programmes d'essais d'aptitude à l'emploi*





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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.

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 4180 was prepared by Technical Committee ISO/TC 122, *Packaging*, Subcommittee SC 3, *Performance requirements and tests for means of packaging, packages and unit loads (as required by ISO/TC 122)*.

This first edition of ISO 4180 cancels and replaces ISO 4180-1:1980 and ISO 4180-2:1980.

# Packaging — Complete, filled transport packages — General rules for the compilation of performance test schedules

## 1 Scope

This International Standard establishes general rules to be used for the compilation of performance test schedules for complete, filled transport packages intended for use within any distribution system except for the packages used for dangerous goods.

For a known distribution environment with experimental data available (case 1), this International Standard provides guide lines for the compilation of appropriate test schedules.

For an unknown distribution environment (case 2), this International Standard provides test schedules in dependence of the test specimen mass and forecast destination.

This International Standard also gives the factors to be considered in assessing the criteria of acceptance of such packages after they have been subjected to a package performance test schedule.

## 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 2206, *Packaging — Complete, filled transport packages — Identification of parts when testing*

ISO 2233, *Packaging — Complete, filled transport packages and unit loads — Conditioning for testing*

ISO 2234, *Packaging — Complete, filled transport packages and unit loads — Stacking tests using a static load*

ISO 2244, *Packaging — Complete, filled transport packages and unit loads — Horizontal impact tests*

ISO 2248, *Packaging — Complete, filled transport packages — Vertical impact test by dropping*

ISO 2873, *Packaging — Complete, filled transport packages and unit loads — Low pressure test*

ISO 4178, *Complete, filled transport packages — Distribution trials — Information to be recorded*

ISO 8318, *Packaging — Complete, filled transport packages and unit loads — Sinusoidal vibration tests using a variable frequency*

ISO 12048, *Packaging — Complete, filled transport packages — Compression and stacking tests using a compression tester*

ISO 13355:2001, *Packaging — Complete, filled transport packages and unit loads — Vertical random vibration test*

EN 14149, *Packaging — Complete, filled transport packages and unit loads — Impact test by rotational drop*

## 3 Terms and definitions

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

**3.1**
**performance test schedule**
single laboratory test, or series of tests, intended to ascertain the performance, under working conditions, of the subject under test

**3.2**
**complete, filled transport package**
packaging, including contents, prepared for distribution

NOTE ISO 21067 [6] provides terminology relating to packaging.

**3.3**
**distribution system**
operations which take place after a package has been filled and closed, including all handling, transport and storage operations up to and including delivery to the user

## 4 Distribution systems

Distribution systems exist in great variety and complexity, but however great the complexity, they may be considered to be combinations of a number of simple elements. These simple elements are:

a) transport of packages from one point to another, with or without change of mode of transport (where transport shall be considered to include the loading and unloading operations);

b) storage.

## 5 Hazards

During distribution, a transport package is subjected to a number of hazards which might cause damage. These hazards are the result of a number of factors, the most important of which are:

a) the characteristics of the distribution system, i. e. the carrier, the mode of transport, the geographic area;

b) the design of the package, i.e. its dimensions, mass and shape and the mechanical characteristic of the materials of which it is composed.

## 6 Tests

### 6.1 General

Laboratory tests on transport packages aim to simulate or represent the distribution hazards.

### 6.2 Appropriate application of tests

The appropriate application of tests requires

a) a knowledge of the stress arising from these hazards, and

b) the capability of reproducing these stresses by a particular test or, alternatively, of producing damage identical to that observed in practice.

### 6.3 Levels of intensity

The levels of intensity selected for the tests could depend on the factors in 6.2 and:

a) the mass of the package;

b) the distance and the geographic location of the destination;

c) the degree of assurance that the package should give;

d) the nature of the contents and the frequency and value of the consignment.

## 7 Determination of criteria for acceptance

The criteria for acceptance of a complete filled transport package might be determined by

— the reduction of quality of the package and/or its contents,

— the extent of loss of package contents,

— the extent of deterioration of the package and/or its contents, or

— whether the damaged package represents a hazard or potential hazard in subsequent distribution, including storage.

In determining the extent of damage that is acceptable the following factors should be considered:

a) the unit value of the contents;

b) the number of units in the complete, filled transport package;

c) the number of complete, filled transport packages in the consignment;

d) the cost of distribution.

In addition it should be considered whether the contents are

— non-dangerous, or

— dangerous.

Methods of quantifying damage to a package are given in Annex A.

## 8 Selection of package attitude

The package attitude selected for use in the test should be the attitude of the package presented by the hazard being simulated by the test.

# 9 Compilation of test schedules

## 9.1 Case 1: distribution system well defined and intensity of hazards determined

In this case, the performance test schedule shall be written using the experimental test data acquired in accordance with ISO 4178. Applicable tests shall be chosen depending on the distribution system. Appropriate test sequence and test intensity shall be chosen.

The steps of the procedure are as follows:

a) identify the simple elements in the distribution system;

b) decide what hazards these elements involve;

c) decide which tests are necessary to represent or simulate these hazards (including, for example, decisions concerning appropriate conditioning, package attitude, interposed hazards, duration of vibration and number of impacts);

d) decide the test sequence;

e) decide what are the test intensities associated with the particular package and distribution system combination concerned.

## 9.2 Case 2: distribution system undefined and intensity of hazards unknown

Very often, the package manufacturer does not have a clear knowledge of the distribution system, and the intensities of the hazards are unknown.

In this case, this International Standard provides *recommended* performance test schedules.

Choice criteria are the mass and the destination of the package.

# 10 Case 1

## 10.1 Preferred test sequence

A typical test sequence is:

a) conditioning for testing;

b) climatic treatment;

c) vibration;

d) stacking;

e) impacts.

Other tests may be interposed in the test schedule as appropriate. When circumstances require a different order, this should be reported.

## 10.2 Preferred test parameters

To allow repeatability and reproducibility, test levels and parameters should be chosen among those proposed in this paragraph and should comply with the included recommendations.

## 10.3 Atmospheric conditioning (performed in accordance with ISO 2233)

**Table 1 — Preferred test parameters**

| Temperature | | Relative humidity |
|---|---|---|
| °C | °K | % |
| −55 | 218 | — |
| −35 | 238 | — |
| −18 | 255 | — |
| +5 | 278 | 85 |
| +20 | 293 | 65 |
| +20 | 293 | 90 |
| +23 | 296 | 50 |
| +27 | 300 | 65 |
| +30 | 303 | 65 |
| +30 | 303 | 90 |
| +35 | 308 | 65 |
| +35 | 308 | 90 |
| +40 | 313 | 65 |
| +40 | 313 | 90 |
| +55 | 328 | 30 |

## 10.4 Low pressure tests (performed in accordance with ISO 2873)

**Table 2 — Preferred test pressures**

| Pressure | Corresponding altitude | |
|---|---|---|
| hPa | m | |
| 800 | about 2 000 | (a pass through the Alps) |
| 650 | about 3 500 | (aircraft) |
| 550 | about 5 000 | (the city of La Paz, Bolivia) |
| 360 | about 8 000 | (unpressurized aircraft) |
| 190 | about 12 000 | (unpressurized aircraft) |

## 10.5 Horizontal impact (performed in accordance with ISO 2244)

The test can be defined using an impact velocity chosen from Table 3.

**Table 3 — Preferred impact test velocities**

| Preferred test velocities<br>m/s |
|---|
| 1,0 |
| 1,3 |
| 1,5 |
| 1,8 |
| 2,2 |
| 2,7 |
| 3,3 |
| 4,0 |
| 5,0 |
| 7,0 |

These shocks can also be defined in terms of wave shape, peak acceleration and duration. This method of defining shocks is only possible where a test lab has a sophisticated acquisition system and suitable accelerometers. Recording these data improves the quality of the test. The severity is well determined and the reproducibility is assured.

In this case, test parameters are given in Tables 4 to 6.

**Table 4 — Shock definitions: preferred wave shapes**

| Preferred wave shapes |
|---|
| Half sine |
| Sawtooth |
| Trapezium |

**Table 5 — Shock definitions: preferred duration**

| Preferred duration<br>ms |
|---|
| 6 |
| 11 |
| 20 |
| 30 |
| 40 |
| 50 |
| 100 |

**Table 6 — Shock definitions: preferred peak acceleration**

| Preferred peak acceleration<br>$m/s^2$ |
|---|
| 50 |
| 100 |
| 150 |
| 200 |
| 300 |
| 400 |
| 500 |
| 600 |
| 800 |
| 1 000 |

The horizontal impact test is defined by choosing an impact velocity or duration and peak acceleration from Table 3, Table 5 or Table 6 for the type of waveform desired (see Table 4).

## 10.6 Vertical impact (performed in accordance with ISO 2248)

The fall height shall be chosen from Table 7.

**Table 7 — Preferred test heights**

| Preferred test heights<br>mm |
|---|
| 50 |
| 100 |
| 150 |
| 200 |
| 300 |
| 400 |
| 500 |
| 600 |
| 800 |
| 1 000 |
| 1 200 |
| 1 500 |
| 1 800 |
| 2 100 |

These shocks can also be defined in terms of wave shape, duration and peak acceleration. This method of defining shocks is only possible where a test lab has a sophisticated acquisition system and suitable accelerometers. Recording these data improves the quality of the test. The severity is well determined and the reproducibility is assured.

In this case, test parameters shall be from Table 4, Table 8 and Table 9.

**Table 8 — Shock definitions: preferred durations**

| Preferred durations<br>ms |
|---|
| 6 |
| 11 |
| 20 |
| 30 |
| 40 |
| 50 |
| 70 |
| 100 |

**Table 9— Shock definitions: preferred peak accelerations**

| Preferred peak accelerations<br>$m/s^2$ |
|---|
| 50 |
| 100 |
| 150 |
| 200 |
| 300 |
| 400 |
| 500 |
| 600 |
| 800 |
| 1 000 |
| 1 200 |
| 1 500 |

The vertical impact test is defined by choosing a fall height (i.e. impact velocity) or duration and peak acceleration from Tables 7 to 9, for the type of waveform desired (see Table 4).

## 10.7 Random vibration tests (performed in accordance with ISO 13355)

### 10.7.1 Mounting of package on the test vibration table

If the method of fastening the packaged product to a transportation vehicle is known, that method shall, where practicable, be replicated.

If the packaged product is capable of being fastened to a transportation vehicle in a number of known ways then, from engineering knowledge of the dynamic behaviour of the product, the worst case shall be selected so that faults are most likely to be revealed. If this is not apparent, a selection of worst cases shall be made from amongst the various possibilities.

Where the packaged product is fastened to a transportation vehicle but the method varies in an unpredictable way, it shall be mechanically connected to the test apparatus as detailed in the relevant specification. This may be in a manner which only engineering judgement can decide and shall be based upon faults considered most likely to be revealed.

If the packaged product is intended, or is likely, to be carried in a transportation vehicle without being fastened down, or with some degree of freedom, that method shall, where practicable, be replicated.

If the packaged product is intended to be fastened to a transportation vehicle but it is considered likely that, in practice, it might not be fastened down, the relevant specification may require the test without clamping to the test table. This may be in addition to the appropriate test where the product is fastened down.

### 10.7.2 Test power spectral densities (PSD)

When performing the random vibration test, use the spectrum given in ISO 13355:2001, Annex A. If another spectrum is desired, the criteria to determine test power spectral densities (PSD) shall be as follows.

When recordings relevant to the distribution system are available, the test spectrum derived from the recordings shall not have a number of break points exceeding 15.

The preferred test parameters are given in Tables 11 to 14.

**Table 11 — Preferred random test parameters: test frequency ranges**

| Preferred test frequency ranges<br>Hz |
|---|
| 3 to 200 |
| 5 to 300 |
| 5 to 500 |

**Table 12 — Preferred random test parameters: root mean square accelerations**

| Preferred root mean square accelerations<br>$m/s^2$ |
|---|
| 3 |
| 5 |
| 7,5 |
| 10 |
| 12,5 |
| 15 |

**Table 13 — Preferred random test parameters: test durations**

| Preferred test durations<br>min |
|---|
| 10 |
| 20 |
| 30 |
| 40 |
| 60 |
| 90 |
| 120 |

**Table 14 — Preferred random test parameters: stack height for superimposed loads**

| Height of the stack<br>m |
|---|
| 1,50 |
| 1,80 |
| 2,50 |
| 3,50 |

## 10.8 Stacking

### 10.8.1 Stacking (performed in accordance with ISO 2234)

**Table 15 — Stacks: preferred heights of stack**

| Preferred heights of stack<br>m |
|---|
| 1,50 |
| 2,00 |
| 2,50 |
| 3,50 |
| 5,00 |
| 7,00 |

**Table 16 — Stacks: duration under load**

| Duration under load |
|---|
| 1 day |
| 2 days |
| 3 days |
| 1 week |
| 2 weeks |
| 3 weeks |
| 4 weeks |

### 10.8.2 Stacking test using a compression tester (performed in accordance with ISO 12048)

**Table 17 — Preferred loads**

| Preferred loads<br>N |
|---|
| 250 |
| 500 |
| 750 |
| 1 000 |
| 1 500 |
| 2 000 |
| 2 500 |
| 3 000 |
| multiples of 1 000 |

## 10.9 Test simulating different hazards

In some cases the distribution system can include different hazards described in the relevant International Standards, such as the repetitive shocks test (ISO 2247), the toppling test (ISO 8768), the rolling test (ISO 2876), the stability test (ISO 10531) and the water spray test (ISO 2875).

In this case, a test representing these conditions should be added to the test schedules to fully reproduce the environmental conditions.

In case a compression of the sides is possible (package that can be clamped), a compression test on the sides interested by the clamp is necessary.

# 11 Case 2

For the reasons given in 9.2, this clause provides *recommended* performance test schedules.

The test schedules may be changed as agreed by the involved stakeholders. In this case, the change and the reason should be added to the test report. Drop heights for these test schedules are given in Table 19.

Choice criteria are the mass and the destination of the package.

The following three classes of packages exist, depending on the mass of the package.

a) Gross mass $\leqslant$ 30 kg (see Table 18).

b) Gross mass $>$ 30 kg and $\leqslant$ 100 kg (see Table 20).

c) Gross mass $>$ 100 kg (see Table 21).

The following three classes of severities exist, depending on the destination of the package.

— Level 1: very long range transportations ($>$ 2500 km), or expected poor conditions of transport infrastructures.

— Level 2: long range national transportations or international transportations, with adequate roads and rails, in a temperate climate.

— Level 3: short range national transportations ($<$ 200 km), without particular hazards.

**Table 18 — Test schedules and intensities for packages of mass less than 30 kg**

| | | | Intensity | | | Notes |
|---|---|---|---|---|---|---|
| **Basic sequence** | **Test type** | **Reference standard** | **lowest** **3** | **2** | **highest** **1** | |
| Conditioning | Atmospheric | ISO 2233 | 23 °C at 50 % relative humidity | | | If other conditions are desired choose atmospheric conditioning from Table 1 |
| Shock | Drop tests | ISO 2248 | See Table 9 | | | Choose drop height depending upon package mass.<br>Perform drops on three faces: 3, 2 and 5, in accordance with ISO 2206, four edges and four corners surrounding the base |
| Compression | Static load | ISO 12048 | Maximum load | Maximum load × 2 | Maximum load × 3 | Maximum load [package mass × (number of stacked elements − 1)]<br>Apply load and release |
| Transport vibration | Vibration | Random PSD ISO 13355 | Nominal PSD ISO 13355 15 min | Nominal PSD ISO 13355 90 min | Nominal PSD ISO 13355 180 min | PREFERRED TEST<br>Perform the test along the vertical axis<br>If the vertical axis is undefined and the orientation of the package during transportation is unpredictable, perform the test along three axis (the test time along each axis is 5 min, 30 min or 60 min) |
| | | ISO 8318 Sinusoidal | 7 $m/s^2$ 15 min | 7 $m/s^2$ 90 min | 7 $m/s^2$ 180 min | It is recommended to conduct the test with variable frequency |
| Transport vibration | Repetitive shock | Random PSD ISO 13355 | Nominal PSD ISO 13355 10 min | Nominal PSD ISO 13355 20 min | Nominal PSD ISO 13355 30 min | Use random PSD with no clamping of units to table surface |
| Compression | Static load | ISO 12048 | Apply maximum load for 24 h | | | Impose maximum expected load [package mass × (number of stacked elements − 1)] |
| Shock | Drop tests | ISO 2248 | See Table 9 | | | Choose drop height depending upon package mass.<br>Perform drops on three faces: 3, 2 and 5 in accordance with ISO 2206, four edges and four corners surrounding the base |

**Table 19 — Drop height**

| | Test intensity (height in cm) | | |
|---|---|---|---|
| **Mass** (kg) | **3** | **2** | **1** |
| 0 to 10 | 60 | 80 | 100 |
| 10,1 to 20 | 45 | 60 | 80 |
| 20,1 to 30 | 30 | 45 | 60 |

**Table 20 — Test schedules and intensities for packages of gross mass > 30 kg and ⩽ 100 kg**

| | | | Intensity | | | Notes |
|---|---|---|---|---|---|---|
| **Basic sequence** | **Test type** | **Reference standard** | **lowest 3** | **2** | **highest 1** | |
| Conditioning | Atmospheric | ISO 2233 | 23 °C at 50 % relative humidity | | | If other conditions are desired choose atmospheric conditioning from Table 1 |
| Shock | Horizontal impact test | ISO 2244 | 1 m/s | 1,5 m/s | 2 m/s | Apply impact once on each side face |
| Compression | Static load | ISO 12048 | Maximum load | Maximum load × 2 | Maximum load × 3 | Maximum load [package mass × (number of stacked elements − 1)]<br>Apply load and release |
| Transport vibration | Vibration | Random PSD ISO 13355 | Nominal PSD ISO 13355 15 min | Nominal PSD ISO 13355 90 min | Nominal PSD ISO 13355 180 min | PREFERRED TEST<br>Perform the test along the vertical axis.<br>If the vertical axis is undefined and the orientation of the package during transportation unpredictable, perform the test along three axis (the test time along each axis is 5 min, 30 min or 60 min) |
| | | ISO 8318 Sinusoidal | 7 $m/s^2$ 15 min | 7 $m/s^2$ 90 min | 7 $m/s^2$ 180 min | It is recommended to conduct the test with variable frequency |
| Transport vibration | Repetitive shock | Random PSD ISO 13355 | Nominal PSD ISO 13355 10 min | Nominal PSD ISO 13355 20 min | Nominal PSD ISO 13355 30 min | Use random PSD with no clamping of units to table surface |
| Compression | Static load | ISO 12048 | Apply maximum load for 24 h | | | Impose maximum expected load [package mass × (number of stacked elements − 1)] |
| Shock | For package ⩽ 70 Kg | ISO 2248 Vertical impact | 15 cm | 30 cm | 40 cm | Perform one drop on the base, one drop on each edge of the base and one drop on each corner of the base |
| Shock | Drop tests for package > 70 Kg | EN 14149 Rotational drop | 10 cm | 20 cm | 30 cm | Perform drop on two adjacent edges of the base of the package from the prescribed height |

**Table 21 — Test schedules and intensities for packages of gross mass > 100 kg**

| | | | Intensity | | | Notes |
|---|---|---|---|---|---|---|
| **Basic sequence** | **Test type** | **Reference standard** | **lowest** **3** | **2** | **highest** **1** | |
| Conditioning | Atmospheric | ISO 2233 | 23 °C at 50 % Relative Humidity | | | If other conditions are desired choose atmospheric conditioning from Table 1 |
| Shock | Horizontal impact test | ISO 2244 | 1 m/s | 1,5 m/s | 2 m/s | Apply impact once on each side face |
| Compression | Static load | ISO 12048 | Maximum load | Maximum load × 2 | Maximum load × 3 | Maximum load [package mass × (number of stacked elements − 1)] Apply load and release |
| Transport vibration | Vibration | Random PSD ISO 13355 | Nominal PSD ISO 13355 15 min | Nominal PSD ISO 13355 90 min | Nominal PSD ISO 13355 180 min | PREFERRED TEST Perform test in vertical direction only |
| | | ISO 8318 sinusoidal | 7 $m/s^2$ 15 min | 7 $m/s^2$ 90 min | 7 $m/s^2$ 180 min | It is recommended to conduct the test with variable frequency |
| Transport vibration | Repetitive shock | Random PSD ISO 13355 | Nominal PSD ISO 13355 10 min | Nominal PSD ISO 13355 20 min | Nominal PSD ISO 13355 30 min | Use random PSD with no clamping of units to table surface |
| Compression | Static load | ISO 12048 | Apply maximum load for 24 h | | | Impose maximum expected load [package mass × (number of stacked elements − 1)] In case a compression of the sides is possible (package that can be clamped), a compression test on the sides affected by the clamp is necessary |
| Shock | Drop tests | ISO 14149 Rotational drop | 10 cm | 20 cm | 30 cm | Perform drop on two adjacent edges of the base of the package from the prescribed height |

# 12 Documentation

## 12.1 Test specification

Before starting the tests, a test specification shall be written, including the following particulars.

a) Reference to this International Standard.

b) Information relevant to the kind of distribution, including recordings acquired.

c) A description of each test, of the items to be tested and of their number.

d) The criteria of acceptance.

## 12.2 Test report

The final report shall include

a) a reference to this International Standard,

b) a unique identification of the report,

c) the name, title and signature of persons accepting test responsibility for the test report,

d) detailed information on the package under testing and the distribution system, including the content,

e) a description of the test schedule adopted,

f) any modification to the original test plan and relevant clauses,

g) the report of each test performed,

h) any deviation from the test method described in this International Standard,

i) the condition of the item after the test schedule, and observations regarding the test that caused the maximum hazard to the item,

j) the date of the test, and

k) the place of testing.

# Annex A
(informative)

# Methods of quantifying damage to a package and/or its contents

## A.1 Extent of damage

The extent of damage may be quantified as follows:

a) loss of content by number, volume or mass;

NOTE Loss by leakage is also related to time.

b) damage to contents measured by appropriate test methods, for example moisture content of biscuits; loss of calibration of an instrument;

c) other damage to the package and/or its contents including

1) changes in dimension,

2) dimensions of damage (for example, length of splits, area of corrosion), and

3) time or cost of repair.

# Bibliography

[1] ISO 2247, *Packaging — Complete, filled transport packages and unit loads — Vibration tests at fixed low frequency*

[2] ISO 2875, *Packaging — Complete, filled transport packages and unit loads — Water-spray test*

[3] ISO 2876, *Packaging — Complete, filled transport packages — Rolling test*

[4] ISO 8768, *Packaging — Complete, filled transport packages — Toppling test*

[5] ISO 10531, *Packaging — Complete, filled transport packages — Stability testing of unit loads*

[6] ISO 21067, *Packaging — Vocabulary*

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