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Environmental testing –
Part 2-18: Tests – Test R and guidance: Water

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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ENVIRONMENTAL TESTING –

Part 2-18: Tests – Test R and guidance: Water

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60068-2-18 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test.

This third edition cancels and replaces the second edition published in 2000. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) addition of the new test method Rb 3.

The text of this standard is based on the following documents:

FDIS	Report on voting
104/719/FDIS	104/722/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

~~It is the intention of this part of IEC 60068 to fulfil the function of a basic publication[1)] by making water tests available to product committees.~~

A number of water tests are described in other IEC publications. Some of them are well established, for example, the test for classification of the second characteristic numeral of the IP Code, of IEC 60529.

This document incorporates the majority of the most widely used tests, as well as making available further methods and increasing the number of severities.

~~[1)] IEC Guide 108:1994, *The relationship between technical committees with horizontal functions and product committees and the use of basic publications*~~

ENVIRONMENTAL TESTING –

Part 2-18: Tests – Test R and guidance: Water

1 Scope ~~and object~~

This part of IEC 60068 provides methods of test applicable to products which, during transportation, storage or in service, ~~may~~ can be subjected to falling water drops, impacting water, immersion or high pressure water impact. The primary purpose of water tests is to verify the ability of enclosures, covers and seals to maintain components and equipment in good working order after and, when necessary, under a standardized drop field or immersion in water.

These tests are not corrosion tests and ~~should not~~ cannot be considered and used as such.

~~The effects of a large temperature difference between the water and the specimen, such as increased water ingress resulting from pressure changes, as well as thermal shock, are not simulated.~~

Established water tests in other standards are not intended to simulate natural rainfall and their quoted intensities are too high to be adopted for that purpose. Therefore, in addition to the high-intensity severities, test R includes an artificial rain test based upon natural conditions but not taking into account high wind speeds generally associated with natural rain.

Guidance is given on the applicability of the tests and the severities to be selected.

2 Normative references

~~The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60068. For dated references, subsequent amendments to, or revisions of, these publications do not apply. However, parties to agreements based on this part of IEC 60068 are encouraged to investigate the possibility of applying the most recent edition of the normative documents indicated below. For undated references, the latest edition of the normative documents referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards~~

~~IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*~~

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardisation at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
rain
precipitation in the form of water drops

Note 1 to entry: Both the amount that falls and the actual falling action of the water drops are often called rainfall.

3.2
drizzle
precipitation in the form of very small, numerous and uniformly dispersed water drops that may appear to float while following air currents

3.3
raindrop
drop of water having a diameter greater than 0,5 mm falling through the atmosphere

3.4
drizzledrop
drop of water having a diameter of 0,2 mm to 0,5 mm falling through the atmosphere

3.5
R
rainfall or drizzle intensity
amount that falls per unit of time

Note 1 to entry: Rainfall intensity (R) is given in millimetres per hour (mm/h) where 1 l/(m^2 · h) equals 1 mm/h.

3.6
D_{50}
median volume diameter
diameter of a drop whose size is such that 50 % of the volume of water reaching the ground is comprised of smaller (or larger) drops

Note 1 to entry: Median volume diameter can be calculated using the formula:

$D_{50} = 1{,}21\ R^{0{,}19}$ (mm)

where R is the rainfall intensity (see 3.5).

4 Survey of water tests

4.1 General

This survey indicates the general structure of the various tests included in this document.

The structuring of the different tests is given in Figure 1.

4.2 Description of tests R: water

The water tests are structured into three groups.

- Ra: "falling drops" which, in principle, is a test with artificial rain and a test simulating falling drops from condensation or leakage.
- Rb: "impacting water" where water jets impinge upon the test specimen with a certain force and may assume any angle towards the test specimen.
- Rc: "immersion" where the test specimen is immersed in water to specified depths or equivalent pressures.

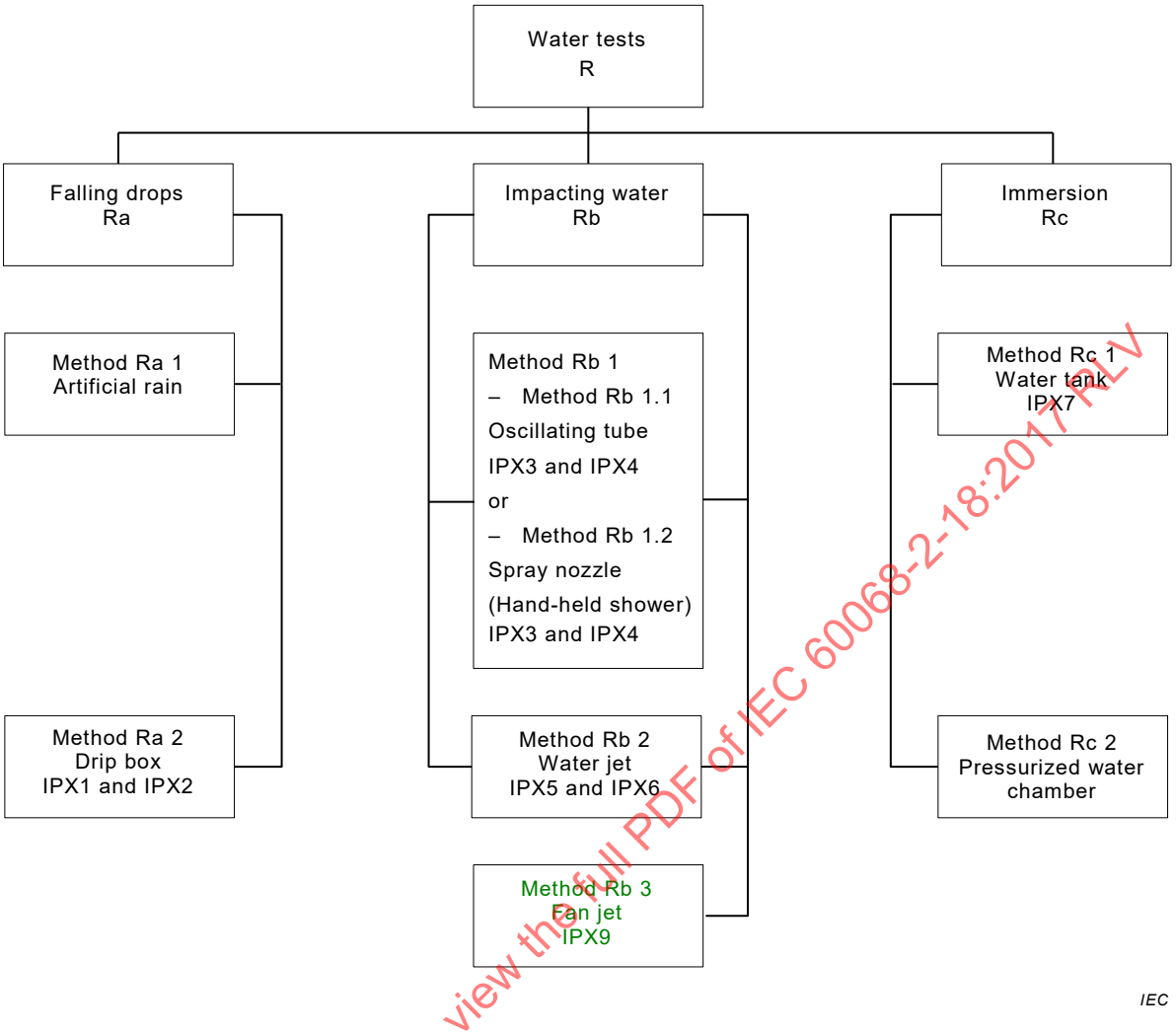


Figure 1 – Structuring of test methods and equivalence with the IP Code of IEC 60529

5 Test Ra: falling drops

5.1 Object

This test is applicable to products which, during transportation, storage or in service may be exposed to vertical falling drops, the origin of these being, for example, natural rain, seepage or condensation. It shall be clearly stated in the relevant specification whether a product hereinafter referred to as a specimen has to function during testing or merely to survive conditions of falling drops. In either case, the relevant specification shall always ~~prescribe~~ specify the acceptable tolerances in performance.

5.2 Method Ra 1: artificial rain

5.2.1 General description of the test

The test specimen is mounted on an appropriate fixture or base support. It is then subjected to falling waterdrops, which simulate natural rain.

The basic requirements for the test apparatus are as follows.

- Drop-generating nozzle or nozzles (see C.2.1 and Figure C.1).
- Fixture for the specimen

The fixture shall simulate as far as possible the mounting of the specimen when in service; for example, for wall-mounted equipment the fixture shall simulate a wall.

- Support of the test specimen

  The support shall have a base area which is smaller than the base area of the specimen. The support shall be either a turntable which has a rotation speed of 1 r/min and the eccentricity (distance between turntable axis and specimen axis) is approximately 100 mm, or a table which does not turn. The support shall be able to hold the specimen in any test position and, if necessary, be tilted to a maximum of 90° from the vertical plane.

- Water supply with controls

  The water used for the test shall be fresh tap water of good quality. In order to avoid clogging of the nozzles, the water shall be filtered and may be demineralized. Details of the characteristics of the water are given in Annex A. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

5.2.2 Severities

The severities, as indicated by intensity (and associated drop-size distribution), duration and tilt angle of specimen shall be ~~prescribed~~ specified in the relevant specification. The values shall be selected from those given below, a longer duration may be specified in the relevant specification. Wind-driven rain is not simulated by this test as the wind velocity is not a parameter of test.

- Intensity, mm/h and (associated drop-size distribution, mm):

  10 ± 5 (D_{50} = 1,9 ± 0,2); 100 ± 20 (D_{50} = 2,9 ± 0,3); 400 ± 50 (D_{50} = 3,8 ± 0,4).

- Duration, min:

  10, 30, 60, 120.

- Tilt angle α, degrees:

  0, 15, 30, 60, 90.

~~NOTE The relevant specification may prescribe a longer duration.~~

5.2.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if ~~prescribed~~ specified in the relevant specification.

5.2.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification. All features of the specimen likely to affect the test result, for example surface treatment, enclosures, covers or seals, shall be inspected to ensure that the instructions of the relevant specification have been followed.

5.2.5 Testing

The specimen shall be mounted on the support either

- in its normal operating position, as ~~prescribed~~ specified in the relevant specification; or
- tilted from the normal operating position and provision made for rotating the specimen in a plane perpendicular to the tilted axis. The rotation may be achieved by a rotating support table or by repositioning the specimen at regular intervals during the test. Alternatively, the specimen can be oscillated through an arc of 270° to avoid the need for slip-ring contacts.

The relevant specification shall specify the tilt angle or angles, the face or faces to be exposed to the drop field and the duration of exposure for each side, or whether the specimen shall be continuously rotated or oscillated through 270°. See also Figure 2.

The specimen shall be subjected to artificial rain with severities selected from 5.2.2 and ~~prescribed by~~ specified in the relevant specification.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing the specimen in the energized condition.

5.2.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

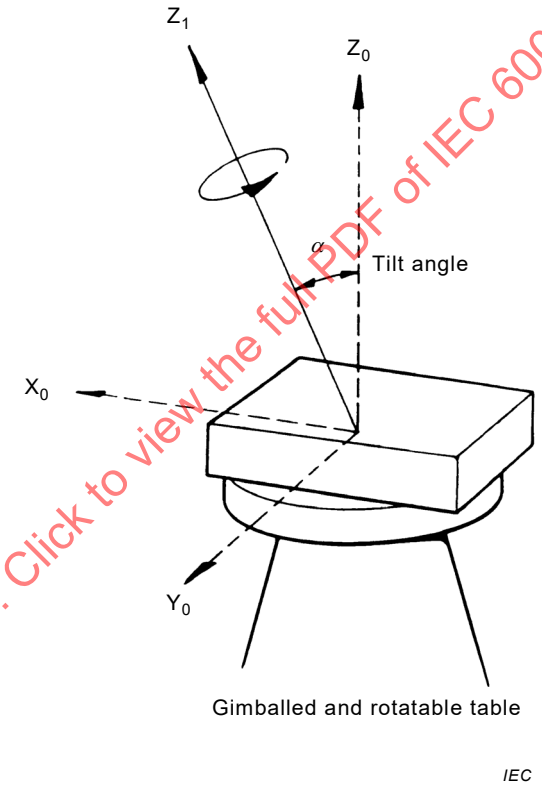


Figure 2 – Test Ra, definitions of angles and axes

5.2.7 Final measurements

The specimen shall be examined for ingress of water and submitted to visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification.

Any ingress of water should be quantified if possible and reported.

5.2.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

Subclause

a) Severities* 5.2.2
b) Preconditioning 5.2.3
c) Initial measurements* 5.2.4
d) Mounting of specimen* 5.2.5
e) Specimen position or positions during testing* 5.2.5
f) State of the specimen during testing* 5.2.5
g) Intermediate measurements 5.2.5
h) Recovery 5.2.6
i) Final measurements* 5.2.7

5.3 Method Ra 2: drip box

5.3.1 General description of the test

The test specimen is mounted on an appropriate fixture placed under the drip box. The test specimen is subjected to water drops, which simulate water falling as a result of condensation or leakage.

The basic requirements for the test apparatus are as follows:

- Drip box

  The drip box shall normally have a base area larger than the projected area of the specimen. If the base of the drip box is smaller than that of the specimen under test, the latter may be divided into several sections, the area of each section being large enough to be covered by the dripping water. The test is continued until the whole area of the specimen has been sprinkled for the specified time. The drip box shall be capable of providing a uniform drop field with a precipitation of the specified intensity.

  The grid pattern of the nozzles shall be 20 mm (for IP Code tests) or 25 mm. The distance from the bottom of the drip box to the highest point of the specimen shall be adjustable to either 0,2 m or 2 m. A suitable drip-box layout is described in C.2.2 and in Figure C.2.

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting of the specimen when in service; for example, for wall-mounted equipment the fixture shall simulate a wall.

- Support of the test specimen

  The support shall have a base area which is smaller than the base area of the specimen. The support shall either be a turntable which has a rotation speed of 1 r/min and an eccentricity (distance between turntable axis and specimen axis) of approximately 100 mm, or a table which does not turn. The support shall be able to hold the specimen in any test position and, if necessary, be tilted to a maximum of 45° from the vertical plane.

- Water supply with controls

  The water used for the test shall be fresh tap water of good quality. In order to avoid clogging of the nozzles, the water shall be filtered and may be demineralized. Details of the characteristics of the water are given in annex A. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

5.3.2 Severities

The severities, as indicated by drop falling height, tilt angle of specimen, duration and water intensity, shall be ~~prescribed~~ specified in the relevant specification. The values shall be selected from the following:

- Drop falling height, (h), m: 0,2; 2
- Tilt angle α, degrees: 0; 15; 30; 45
- Duration, min: 3; 10; 30; 60

NOTE The 3 min duration applies only when a tilt angle of 0° is specified.

- Water intensity, mm/h: $60\ ^{+30}_{0}$; $180\ ^{+30}_{0}$

5.3.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if ~~prescribed~~ specified in the relevant specification.

5.3.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification. All the features of the specimen likely to affect the test result, for example, surface treatment, covers or seals, shall be inspected to ensure that the instructions of the relevant specification have been followed.

5.3.5 Testing

The specimen shall be mounted on the support in its normal operating position under the drip box. The support shall then either be rotated or tilted to the specified angle in each of the four positions of tilt. These positions are on either side of the vertical in two mutually perpendicular planes. If a special mounting condition is required (for example, wall or ceiling), it shall be ~~prescribed by~~ specified in the relevant specification.

In both cases, the test shall be carried out in the conditions specified in 5.3.1 and the severity selected from 5.3.2.

In the case of tilted support, the duration shall be divided equally between the four positions.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made. Appropriate safety precautions shall be taken when testing the specimen in the energized condition.

5.3.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

5.3.7 Final measurements

The specimen shall be examined for ingress of water and submitted to visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification.

Any ingress of water should be quantified if possible and reported.

5.3.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

Subclause

a) Severities* 5.3.2
b) Preconditioning 5.3.3
c) Initial measurements* 5.3.4
d) Mounting of specimen* 5.3.5
e) Specimen position or positions during testing* 5.3.5
f) State of the specimen during testing* 5.3.5
g) Intermediate measurements 5.3.5
h) Recovery 5.3.6
i) Final measurements* 5.3.7

6 Test Rb: impacting water

6.1 Object

This test is applicable to products which, during transportation, storage or in service may be subjected to impacting water. The origin for this can be water from cloudbursts, heavy driving rain, sprinkler systems, pressure cleaning, spray from wheels, sluicing or breaking seas. The relevant specification should clearly ~~prescribe~~ specify whether a product tested separately, hereinafter referred to as a specimen, has to function during testing or merely survive conditions of impacting water. In either case, the relevant specification shall always ~~prescribe~~ specify the acceptable tolerances in performance.

6.2 Method Rb 1: oscillating tube and spray nozzle

6.2.1 General description of the test

The tests are intended to simulate spraying or splashing water, for example, the results of water action of sprinkler systems. Guidance for this test is given in Annex D. The test is made using either the test device described in Figure D.1 or the test device described in Figure D.3 in accordance with the relevant specification. The test specimen is mounted on an appropriate fixture and is subjected to impacting water generated from either a semicircular tube or a spray nozzle.

6.2.2 Method Rb 1.1: oscillating tube

6.2.2.1 Test apparatus

The basic requirements for the test apparatus are as follows.

- Oscillating tubes

  Three types of tube may be used. The tube shall be provided with nozzles of either 0,4 mm diameter for type 1 and type 2 or 0,8 mm diameter for type 3, at a 50 mm centre-to-centre distance over an arc of 60° on either side of the vertical for type 1 or 90° on either side of the vertical for type 2 and type 3. The tube shall be able to oscillate through an angle of 60° on either side of the vertical for type 1 or 180° on either side of the vertical for type 2 and type 3.

  The maximum acceptable radius of the oscillating tubes, type 1 and type 2 is 1 600 mm. For oscillating tube type 3, the radius shall not exceed 800 mm. The radius shall be selected in such a way that the clearance between the specimen and the inside of the tube does not exceed 200 mm.

  The relationship between the number of nozzles, each having a mean flow rate of 0,07 l/min or 0,6 l/min and the total flow rate is given in Table 2.

  A suitable apparatus is shown in Figure D.1.

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting structure to be used in the real use of products; for example, for wall-mounted equipment, the fixture shall simulate a wall.

- Support for the specimen

  The support for the specimen shall not be perforated for type 1 and shall be suitably perforated for type 2 and type 3.

- Water supply with controls

  The water used for the test shall be fresh tap water of good quality. In order to avoid clogging of the nozzles, the water shall be filtered and may be demineralized. Details of the characteristics of the water are given in Annex A. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

6.2.2.2 Severities

The severities as indicated by the nozzle angle, water flow rate per hole, tube oscillating angle and duration shall be ~~prescribed~~ specified in the relevant specification. The values shall be selected from those given below.

Any combination of water test severities can be chosen independently. In this case, such a combination shall be stated in the relevant specification.

Type 1 tube

- Nozzle angle α, degrees ±60
- Water flow per hole, l/min 0,07 (1 ± 5 %)
- Tube oscillating angle β,degrees ±60
- Duration, min 2 × 5

Type 2 tube

- Nozzle angle α, degrees ±90
- Water flow per hole, l/min 0,07 (1 ± 5 %)
- Tube oscillating angle, β degrees ±180 (approximately)
- Duration, min 10, 30, 60

Type 3 tube

- Nozzle angle α, degrees ±90
- Water flow per hole, l/min 0,6 ± 0,03
- Tube oscillating angle, β degrees ±180 (approximately)
- Duration, min 2 × 5

In some cases, the relevant specification may ~~prescribe~~ specify a longer duration.

6.2.2.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if ~~prescribed~~ specified in the relevant specification.

6.2.2.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification. All features of the specimen likely to affect the test

results, such as surface treatment, covers or sealing, shall be inspected to ensure that the instructions of the relevant specification have been followed.

6.2.2.5 Testing

Three types are described:

Type 1:

The specimen to be tested shall be attached to a fixture, if specified, and shall be placed on the support in its normal operational attitude. For this test, the support shall not be perforated. An oscillating tube as described in Figure D.1, with nozzles over an arc of 60° on either side of vertical shall be chosen having a radius to meet the dimensional requirements of the test specimen. The maximum radius is 1 600 mm. If the test specimen is too large, the spray nozzle test shall be used. The tube is caused to oscillate through an angle of 60° on either side of vertical. The time taken for one complete oscillation from +60° to -60° to +60° shall be approximately 4 s.

Water flow shall be set to the required rate given in Table 1.

The duration of the test shall be 5 min.

The test specimen shall be turned through a horizontal angle of 90° and the test shall be continued for a further 5 min.

If it is not possible to wet all parts of the test specimen, the support shall be moved up and down or the spray nozzle test shall be used.

The relevant specification shall state whether the specimen shall be operated during the test and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing in the energized condition.

Table 1 – Oscillating tube – Relationship of number of nozzles and total water flow to tube radius

	Type 1		Type 2		Type 3	
Tube radius R	Number of open nozzles	Total water flow	Number of open nozzles	Total water flow	Number of open nozzles	Total water flow
mm	N[a]	l/min	N[a]	l/min	N[a]	l/min
200	8	0,56	12	0,84	12	7,2
400	16	1,1	25	1,8	25	15,0
600	25	1,8	37	2,6	37	22,2
800	33	2,3	50	3,5	50	30,0
1 000	41	2,9	62	4,3	–	–
1 200	50	3,5	75	5,3	–	–
1 400	58	4,1	87	6,1	–	–
1 600	67	4,7	100	7,0	–	–

[a] Depending on the actual arrangement of nozzle centres at the specified distance, the number of open nozzles N may be increased by 1.

Type 2:

The test is the same as for type 1 with the following differences:

- the support shall be perforated unless ~~prescribed~~ specified otherwise in the relevant specification;
- the oscillating tube shall have nozzles over an arc of 90° on either side of vertical;
- the tube shall oscillate through an angle of almost 360°, 180° on either side of vertical;
- the time taken for one complete oscillation, from +180° to –180° to +180° shall be approximately 12 s;
- the test duration shall be selected from 6.2.2.2;
- the test specimen is not turned through a horizontal angle of 90° and the test is not continued for any further time;
- the relevant specification shall specify the orientation if it affects the severity of the test.

~~NOTE If orientation affects the severity of the test, the relevant specification shall prescribe it.~~

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing in the energized condition.

Type 3:

The test is the same as for type 2 with the following differences:

- the test duration is 2 × 5 min; that is after 5 min of test, the specimen is turned through a horizontal angle of 90° and the test is continued for a further 5 min.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing in the energized condition.

6.2.2.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

6.2.2.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

6.2.2.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Severities*	6.2.2.2
b) Preconditioning	6.2.2.3
c) Initial measurements*	6.2.2.4
d) Mounting of specimen*	6.2.2.5
e) Specimen position or positions during testing*	6.2.2.5
f) State of the specimen during testing*	6.2.2.5
g) Intermediate measurements	6.2.2.5
h) Recovery	6.2.2.6
i) Final measurements*	6.2.2.7

6.2.3 Method Rb 1.2: spray nozzle

6.2.3.1 Test apparatus

The basic requirements for the test apparatus are as follows.

- Spray nozzle (also known as hand-held shower)

  A spray nozzle with a spray cone of 78° and a moving shield which is able to limit the upper part of the spray cone to 30° from the horizontal. The shield may be removed as specified. The spray nozzle shall have a delivery rate of 10 l/min ± 5 % which necessitates a water pressure of 50 kPa to 150 kPa (0,5 bar to 1,5 bar) (see Figure D.3).

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting structure to be used in real use of products; for example, for wall-mounted equipment, the fixture shall simulate a wall.

- Support for the specimen

  The support for the specimen shall have a base area which is smaller than the base area of the specimen or be suitably perforated.

- Water supply with controls

  The water supply shall be capable of delivering, in a stable flow, at least 10 l/min. The water used for the test shall be fresh tap water of good quality. In order to avoid clogging of the holes, the water shall be filtered and may be demineralized. Details of the characteristics of the water are given in Annex A. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

6.2.3.2 Severities

The specimen surfaces to be sprayed, if not all, shall be specified. The severities as indicated by the use of the shield or not and the test duration shall be ~~prescribed~~ specified in the relevant specification. The severities shall be selected from those given below.

- Moving shield: in use, removed.
- Test duration, min/m^2 test surface, calculated with a tolerance of ±10 % (subject to a minimum duration, min)

  1 (5); 3 (15); 6 (30).

In some cases, the relevant specification may ~~prescribe~~ specify a longer duration.

6.2.3.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if ~~prescribed~~ specified in the relevant specification.

6.2.3.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification. All features of the specimen likely to affect the test result, such as surface treatment, covers or sealing, shall be inspected to ensure that the instructions of the relevant specification have been followed.

6.2.3.5 Testing

The specimen shall be mounted as described in the oscillating tube test procedure (6.2.2.5 type 1 or type 2). The water pressure shall be adjusted to give a delivery rate of 10 (1 ± 5 %) l/min. It shall be kept constant throughout the test. The specified surfaces shall be sprayed for the specified duration and from a distance of (0,4 ± 0,1) m. When the spray nozzle is used as an alternative to the oscillating tube type 2, the moving shield shall be removed and the spray shall be applied at ±180° from vertical.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing in the energized condition.

6.2.3.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

6.2.3.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

6.2.3.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

Subclause

a) Severities* 6.2.3.2
b) Preconditioning 6.2.3.3
c) Initial measurements* 6.2.3.4
d) Mounting of specimen* 6.2.3.5
e) Specimen position or positions during testing* 6.2.3.5
f) State of the specimen during testing* 6.2.3.5
g) Intermediate measurements 6.2.3.5
h) Recovery 6.2.3.6
i) Final measurements* 6.2.3.7

6.3 Method Rb 2: water jet

6.3.1 General description of the test

The test specimen is mounted on a fixture. The test specimen is subjected to a water jet which should simulate wheel spray, or breaking seas. The standard test nozzle is described in D.2.2 and Figure D.4.

The basic requirements for the test apparatus are:

- Hose nozzle

  The hose nozzle shall give a solid water jet and have a free diameter of 6,3 mm and 12,5 mm for the small and large nozzle respectively (see Figure D.4).

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting structure to be used in the real use of products; for example, for wall-mounted equipment, the fixture shall simulate a wall.

  The fixture for the specimen shall have a base area which is smaller than the base area of the specimen or be suitably perforated.

  The fixture ~~must~~ shall have a sufficient strength and stability to withstand the hydrodynamic effect of the water jet.

- Water supply with controls

  The water supply shall be fresh tap water of good quality and shall be capable of delivering at least 100 l/min. The water pressure should be at least 100 kPa at this flow or 1 000 kPa when using the small nozzle. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

6.3.2 Severities

The severities as indicated by the choice of hose nozzle size, flow rate and test duration shall be ~~prescribed~~ specified in the relevant specification. The values shall be selected from those given below:

6,3 mm nozzle

- Flow rate, l/min (and corresponding approximate supply pressure, kPa)

  75 (1 ± 5 %) (1 000)

- Duration, min/m^2 of the test surface, calculated with a tolerance of ±10 % (subject to a minimum duration, min)

  0,3 (1)

6,3 mm nozzle

- Flow rate, l/min (and corresponding approximate supply pressure, kPa)

  12,5 (1 ± 5 %) (30)

- Duration, min/m^2 of the test surface, calculated with a tolerance of ±10 % (subject to a minimum duration, min)

  1 (3); 3 (10)

12,5 mm nozzle

- Flow rate, l/min (and corresponding approximate supply pressure, kPa)

  100 (1 ± 5 %) (100)

- Duration, min/m^2 of the test surface, calculated with a tolerance of ±10 % (subject to a minimum duration, min)

  1 (3); 3 (10); 10 (30)

6.3.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if ~~prescribed~~ specified in the relevant specification.

6.3.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification. All features of the specimen likely to affect the sealing shall be inspected to ensure that the instructions of the relevant specification have been followed.

6.3.5 Testing

The specimen shall be mounted on the fixture in its normal operating position.

The distance from the nozzle to the specimen shall be 2,5 m ± 0,5 m. This distance may be reduced if necessary to ensure proper wetting when spraying upwards. At a distance of 2,5 m from the nozzle, the substantial part of the water jet shall be within a circle of 40 mm for the 6,3 nozzle and 120 mm for the 12,5 mm nozzle.

Unless otherwise specified in the relevant specification, the specimen shall be sluiced on all faces from all practicable directions with a stream of water from a standard test nozzle as shown in Figure D.4.

The size of nozzle, flow rate and test duration shall be as ~~prescribed~~ specified in the relevant specification, selected from 6.3.2.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing specimens in the energized condition.

6.3.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

6.3.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

6.3.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Severities*	6.3.2
b) Preconditioning	6.3.3
c) Initial measurements*	6.3.4
d) Mounting of specimen*	6.3.5
e) Specimen position or positions during testing*	6.3.5
f) State of the specimen during testing*	6.3.5
g) Intermediate measurements	6.3.5
h) Recovery	6.3.6
i) Final measurements*	6.3.7

6.4 Method Rb 3: fan jet

6.4.1 General description of the test

The test is made by spraying the enclosure with a stream of water from a standard test nozzle as shown in Figures D.7, D.8 and D.9.

The set-up for measuring the impact force of the water jet is given in Figure D.10.

The distribution force shall be verified at upper and lower limits of the distance tolerance range (see Figure D.11).

The basic requirements for the test apparatus are as follows.

- Jet nozzle

  The jet nozzle shall give a water fan jet and have an oval-shaped water stream (see Figure D.5).

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting structure to be used in the real use of products; for example, for wall-mounted equipment the fixture shall simulate a wall.

  The fixture for the specimen shall have a base area which is smaller than the base area of the specimen or be suitably perforated.

  The fixture shall have a sufficient strength and stability to withstand the hydrodynamic effect of the water jet.

- Turntable

  The turntable shall rotate with a speed of 5 r/min ± 1 r/min.

- Water supply with controls

The water supply shall be fresh tap water of good quality and shall be capable of delivering water at at least 15 l/min and with a water temperature of 80 °C.

6.4.2 Severities

The water pressure shall be adjusted to give a delivery rate of (15 ± 1) l/min and the water temperature shall be (80 ± 5) °C.

a) For small enclosures (largest dimension less than 250 mm), the enclosure shall be mounted on the test device shown in Figure D.10:

   – turntable speed: 5 r/min ± 1 r/min;

   – spray positions: 0°, 30°, 60°, 90°;

   – distance between nozzle and sample under test shall be 125 mm ± 25 mm.

   The test duration is 30 s per position.

b) For large enclosures (largest dimension greater than or equal to 250 mm), the enclosure shall be mounted as per its intended use. The entire exposed surface area of the enclosure shall be subjected to the spray at some point during the test procedure:

   – spray positions: the enclosure shall be sprayed from all practical directions covering the entire surface area and the spray shall be, as far as possible, perpendicular to the sprayed surface.

   – distance between nozzle and sample under test shall be 175 mm ± 25 mm.

The test duration is 1 min/m^2 of the calculated surface area of the enclosure (excluding any mounting surface), with a minimum duration of 3 min.

6.4.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

6.4.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All features of the specimen likely to affect the sealing shall be inspected to ensure that the instructions of the relevant specification have been followed.

6.4.5 Testing

The test method a) or b) in 6.4.2 shall be selected based on the dimensions of the specimen.

The specimen shall be mounted on the fixture in its normal operating position.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken for highly pressurized and high-temperature water spray and when testing specimens in the energized condition.

6.4.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

6.4.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

6.4.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Severities*	6.4.2
b) Preconditioning	6.4.3
c) Initial measurements*	6.4.4
d) Mounting of specimen*	6.4.5
e) Specimen position or positions during testing*	6.4.5
f) State of the specimen during testing*	6.4.5
g) Intermediate measurements	6.4.5
h) Recovery	6.4.6
i) Final measurements*	6.4.7

7 Test Rc: immersion

7.1 Object

This test is applicable to products which are designed to be resistant to ingress of water, and which, during transportation or in service, may be subjected to immersion. It shall be clearly stated in the relevant specification whether a product tested separately, hereinafter referred to as a specimen, has to function during testing or merely to survive conditions of immersion in water. In either case, the relevant specification shall always ~~prescribe~~ specify the acceptable tolerances in performance.

Normally, fresh tap water is used. If, however, a test is to be made in sea water, this shall be stated in the relevant specification together with the characteristics of the sea water.

The relevant specification may call for measurements of resistivity and pH values.

7.2 Method Rc 1: water tank

7.2.1 General description

The test specimen is subjected to a specified pressure by immersion in a water tank at a specified depth. After testing, the specimen is examined with respect to ingress of water and checked for possible changes of characteristics.

7.2.2 Severities

The severities indicated by head of water and duration shall be ~~prescribed~~ specified in the relevant specification. The values shall be selected from those given below.

- Head of water, m

  0,15; 0,4; 1; 2; 5

  The head of water is defined here as the distance from the surface of the water to the uppermost point of the specimen.

  NOTE The IP classification in IEC 60529 defines the head of water differently.

- Duration, h

  0,5; 2; 24

7.2.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if ~~prescribed~~ specified in the relevant specification.

7.2.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification. All features of the specimen likely to affect the sealing shall be inspected to ensure that the instructions of the relevant specification have been followed.

7.2.5 Testing

The specimen shall be fixed in the position as ~~prescribed~~ specified in the relevant specification and shall be completely immersed in a water tank. A water soluble dye such as fluorescein may be added to the water in order to facilitate indication of leakage.

The specimen shall be subjected to the head-of-water value and for the duration ~~prescribed~~ specified in the relevant specification, selected from 7.2.2.

The initial water temperature shall be between the specimen temperature and 5 K lower. The water temperature shall under no circumstances exceed 35 °C.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing the specimen in the energized condition.

7.2.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

7.2.7 Final measurements

The specimen shall be examined for the ingress of water, and submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

7.2.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Composition of sea water if ~~prescribed~~ specified	7.1
b) Resistivity and pH values of water (test apparatus)	7.1, E.1
c) Severities*	7.2.2
d) Preconditioning	7.2.3
e) Initial measurements*	7.2.4
f) Mounting of specimen*	7.2.5
g) State of the specimen during testing*	7.2.5
h) Intermediate measurements	7.2.5
i) Recovery	7.2.6
j) Final measurements*	7.2.7

7.3 Method Rc 2: pressurized water chamber

7.3.1 General description of the test

The test specimen is subjected to a specified pressure by complete immersion in water in a pressurized water chamber. After testing, the specimen is examined for ingress of water and checked for possible changes of characteristics.

7.3.2 Severities

The severities indicated by the pressure in the chamber and the duration shall be ~~prescribed~~ specified in the relevant specification. The values shall be selected from those given below.

- Overpressure kPa (equivalent head of water, m):

  20 (2) 50 (5) 100 (10) 200 (20) 500 (50)

  1 000 (100) 2 000 (200) 5 000 (500) 10 000 (1 000)

- Duration: h

  2 24 168

7.3.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if ~~prescribed~~ specified in the relevant specification.

7.3.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification. All features of the specimen likely to affect the sealing shall be inspected to ensure that the instructions of the relevant specification have been followed.

7.3.5 Testing

The specimen shall be placed in the position as ~~prescribed~~ specified in the relevant specification and shall be completely immersed in a pressurized water chamber. A water soluble dye such as fluorescein may be added to the water in order to facilitate indication of leakage.

The specimen shall be subjected to the pressure value and for the duration ~~prescribed~~ specified in the relevant specification selected from 7.3.2.

During the test the water shall not differ by more than 5 K from the temperature of the specimen under test. The water temperature shall not exceed 35 °C.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing the specimen in the energized condition.

7.3.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

7.3.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks ~~prescribed by~~ specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

7.3.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Composition of sea water if ~~prescribed~~ specified	7.1
b) Resistivity and pH values of water (test apparatus)	7.1, E.3
c) Severities*	7.3.2
d) Preconditioning	7.3.3
e) Initial measurements*	7.3.4
f) Mounting of specimen*	7.3.5
g) State of the specimen during testing*	7.3.5
h) Intermediate measurements	7.3.5
i) Recovery	7.3.6
j) Final measurements*	7.3.7

Annex A
(informative)

Water characteristics to be considered when writing the relevant specification

A.1 General

Certain characteristics of the water supply for tests in this document are specified in the test methods, for example, drop size, field intensity, velocity of drops and angle of incidence to the specimen. In addition, there are other characteristics of the water supply which may either affect the proper functioning of the test apparatus or have some direct or indirect influence on the specimen.

For the majority of water tests, it is probable that the water will be drawn from a local mains supply; however, such a supply may vary considerably in pressure, temperature and purity. These features will need to be considered in relation to the purpose of the test, for example ingress into the specimen or change of surface characteristics, and the suitability of the water supply will need to be assessed. If the supply is not suitable, it may be subjected to further processing or, if this is not practicable, an alternative source should be provided.

A.2 Purity

A.2.1 General

Mains water supplies normally contain various impurities which may originate from the source, for example the absorption of minerals during its passage through rivers or, as in the case of chlorination, may have been introduced as a disinfectant by chemical processing.

A.2.2 Effect on test specimen

Water tests on certain kinds of specimen may require electrical measurements to be made on the specimen either during or following the spraying period. The electrical measurements may include surfaces directly exposed to the water or those interior surfaces which have been wetted by the ingress of water through vents or leaks. In these circumstances, it may be necessary to ensure that the water from the test apparatus is non-conducting; this implies the need for distilled or deionized water.

Another feature which may need to be considered is that of corrosion of the specimen by the presence of water. The tests in this document are not intended to produce corrosion but this may occur inadvertently under certain conditions. If corrosion is to be avoided, it may be appropriate to use distilled or deionized water; however, it should be noted that pure water may eventually become contaminated by airborne or surface pollutants.

In any event, the appearance of corrosion products is more likely to occur some time after the water test, rather than during the test itself, when the effects of the chemical or electrochemical action have developed.

A.2.3 Effect on test apparatus

Impurities in the water supply to the test apparatus may result in reduced or erratic water flow. The severity of this effect becomes more important with test apparatus operating at lower water pressures. Test methods of test Ra (falling drops) are particularly susceptible to problems of clogging of the water orifice. Filtration of the water supply or the provision of a demineralized supply may be necessary.

A.2.4 Ingress of water into the specimen

Certain features of the water incident to the specimen which affects the ingress, for example, temperature, droplet size, velocity and angle of incidence, are included in the method of test R. However, the composition of the water itself can also affect the entry into any holes or leaks in the specimen. If water is present at the entrance of a hole the flow through the hole is directly proportional to the difference in pressure across it (usually a result of the temperature difference induced by the cooler water) and inversely proportional to the viscosity. The surface tension of the water opposes the flow by reducing the pressure difference and will prevent any flow through very small holes.

Some approximate values of these characteristics of water are given in Table A.1.

A.3 Water quality for tests R

A.3.1 Test Ra: falling drops

The water for these tests should be fresh tap water of good quality. In order to avoid clogging of the nozzles, the water should be filtered and may be demineralized.

Demineralized or distilled water should have a pH value of 6,5 to 7,2 and a resistivity of not less than 500 Ωm.

A.3.2 Test Rb: impacting water

The water for these tests should be fresh tap water of good quality. In order to avoid clogging of the nozzles the water should be filtered and may be demineralized.

A.3.3 Test Rc: immersion

The water for these tests is normally fresh tap water but can be sea water. The water temperature should be (25 ± 10) °C. A water soluble dye such as fluorescein may be added to the water in order to facilitate indication of leakage.

Table A.1 – Typical characteristics of water with approximate values

Relative dielectric constant:	Pure water	80 at 25 °C
Resistivity:	Very pure water	200 000 Ωm
	Deionized water	500 Ωm to 5 000 Ωm
	Mains supply	2,5 Ωm
Surface tension at 20 °C		73×10^{-5} N/cm
Surface tension at 20 °C	With 0,1 g/l wetting agent	43×10^{-5} N/cm
Surface tension at 20 °C	With 0,5 g/l wetting agent	30×10^{-5} N/cm

Annex B
(informative)

General guidance

B.1 General

This document includes a range of water tests either as a field of water drops in air (tests Ra and Rb) or as a homogeneous mass of liquid (test Rc) which may be used to determine their effect on products. The tests are intended to embrace all situations where water in liquid form is a part of the micro-climate surrounding a product, for example, rain, drizzle, hosing, immersion, but excluding erosion resulting from high-velocity water drops.

In the first instance, the effect of interest of a water test is either that of ingress into an enclosure or of a change in the surface characteristics of the product, for example, the lowering of flash-over voltage of electrical isolators. In general, the criterion of success during or following exposure to a water test will depend on the nature of the product and ~~must~~ shall be specified in the relevant specification. For certain products, it may be essential that no water penetrates its protective enclosure, while for other products some water penetration may be allowed. During the product design, it is probable that the degree of protection required of the enclosure will depend on the sensitivity to water of the enclosed parts, although the enclosure may serve a variety of purposes beyond that of protection from water.

Appropriate safety precautions should be taken when testing the specimen in the energized condition.

B.2 Factors affecting the test severity

The factors which contribute to the severity of the test are as follows:

a) intensity of rain or water drop field;
b) velocity of water drops;
c) tilt angle of water drop field to specimen;
d) water pressure (test Rc);
e) temperature difference between water and specimen;
f) water quality.

Annex C
(informative)

Guidance for test Ra

C.1 General

Test Ra: falling drops, comprises two test methods.

Method Ra 1: artificial rain, is applicable for products which may be placed outdoors and unprotected from natural rain.

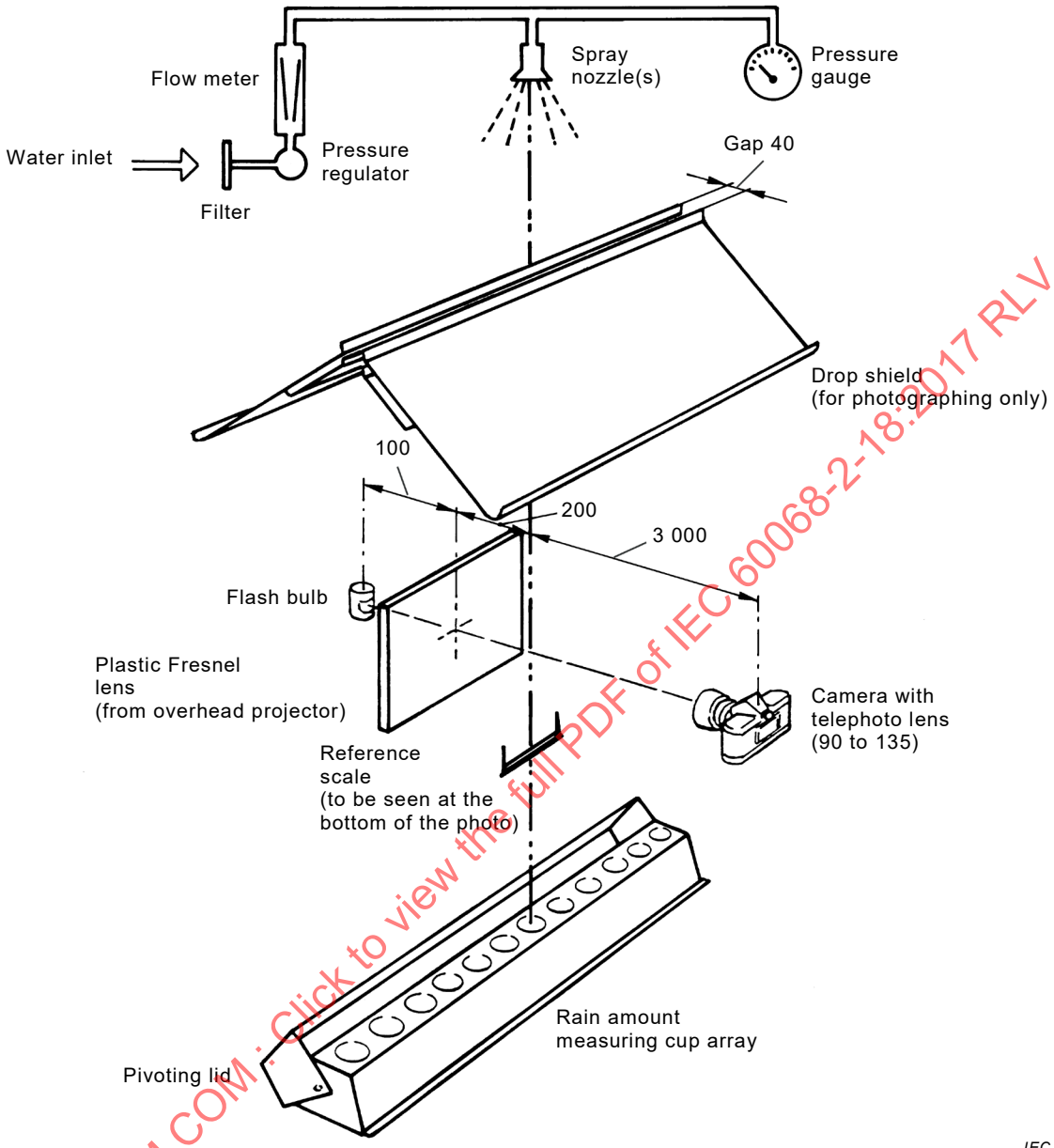
Method Ra 2: drip box, is applicable for products which normally are protected from natural rain, but may be exposed to drops falling as a result of condensation or leakage from upper surfaces.

Before deciding on the test method to be used, an assessment of which test method and test conditions are appropriate ~~must~~ shall be made. The selected test method and severities represent the most severe exposure anticipated for the test item when in ordinary use.

C.2 Example of test apparatus

C.2.1 Method Ra 1: artificial rain

One or more spraying nozzles of commercially available "solid cone" type are arranged to give the ~~prescribed~~ specified intensity (see Figure C.1). A "solid cone" nozzle is one that, within its entire cone area, has a fairly even intensity distribution. This distinguishes it from the plain nozzle which gives a hollow cone type spray pattern.



NOTE 1 The distance between the spray nozzle and the cup area is approximately 2 500 mm.

NOTE 2 The set-up shown is a confirmation device.

Figure C.1 – Test Ra 1, test apparatus and measurement setup for drop sizes and intensity for artificial rain method

C.2.2 Method Ra 2: drip box

The apparatus required consists of a water container of adequate plan dimensions having a number of nozzles, spaced at intervals of 20 mm or 25 mm on a square grid in its base, which permit the water to drip freely and per orifice, at the specified intensities. The size of the container will depend upon the mean area of the specimen to be tested: it may be restricted to such dimensions as to cover selected critical areas of large specimens if permitted by the relevant specification. Figure C.2 gives details of an apparatus currently in use for this test.

This arrangement results in drops of 3 mm to 5 mm in diameter.

C.3 Verification of test apparatus

C.3.1 Intensity

To measure the intensity of the artificial rain as well as that of the drip box, a number of cups placed in a row can be used. The cup array should be equipped with a pivoting lid (see Figure C.1).

The intensity at the location of any one cup is:

$$R = \frac{V \times 6}{A \times t}$$

where

R is the intensity in mm/h;

V is the sampled volume in cm^3;

A is the area of the cup in dm^2;

t is the measuring time in min.

C.3.2 Drop size

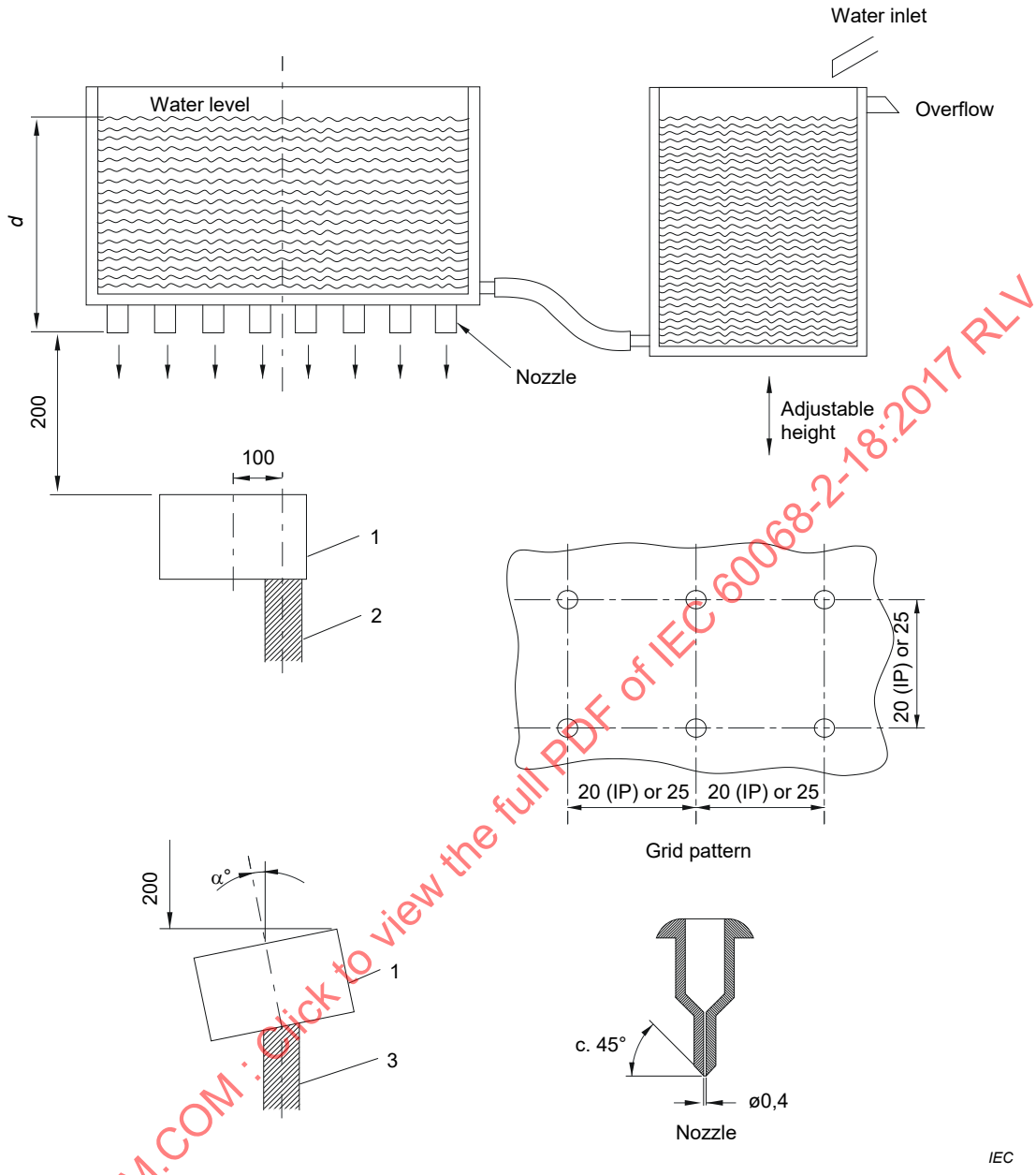
From a picture taken on a thin section through the drop field it is possible to determine the drop size. For the drops to appear clearly and distinctly, a short-duration electronic flash and a Fresnel lens may be used (see Figure C.1). A flash duration of not more than 10 μs, generated, for example, by single-flash triggering of a good stroboscope of the type used in vibration testing is suitable. The drop field size as a function of intensity (or feeding pressure) is fairly stable over time for a specific nozzle set-up.

After initial confirmation the test apparatus will need to be re-checked only when, for example, clogging of the nozzles by impurities may have occurred and been corrected.

C.3.3 Resistivity and pH value

See A.3.1.

Dimensions in millimetres



1 Test specimen

2 Turntable

3 Support

NOTE 1 The intensity is controlled by adjusting the water level (*d*).

NOTE 2 This apparatus is commonly in use and is commercially available, but a different test apparatus, including ~~the~~ different nozzles, ~~may~~ can be used if it can be demonstrated that the results obtained are identical.

Figure C.2 – Test Ra 2, recommended test apparatus for the drip box method

Annex D
(informative)

Guidance for test Rb

D.1 General

Test Rb: impacting water, comprises ~~two~~ three test methods

Method Rb 1: oscillating tube and spray nozzle are applicable for products which may be exposed to water from sprinkler systems or spray from wheels.

Method Rb 2: water jet is applicable for products which may be exposed to flushing, sluicing or breaking seas.

Method Rb3. fan jet nozzle is applicable for products which may be exposed to high pressure and high temperature water spraying.

The selected test method and the severities should represent the most severe exposure for the test item when in ordinary use. Provisions should be made regarding mounting and installation of the specimen, for example by the use of an artificial roof, ceiling or wall and also the procedure with regard to drain holes and ventilation openings.

If method Rb 1 is selected, the oscillating tube should be chosen as the test method, provided the dimensions and shape of the test specimen are such that the radius does not exceed 1,6 m. Where this condition cannot be fulfilled, a spray nozzle should be used.

D.2 Example of test apparatus

D.2.1 Method Rb 1: oscillating tube and spray nozzle

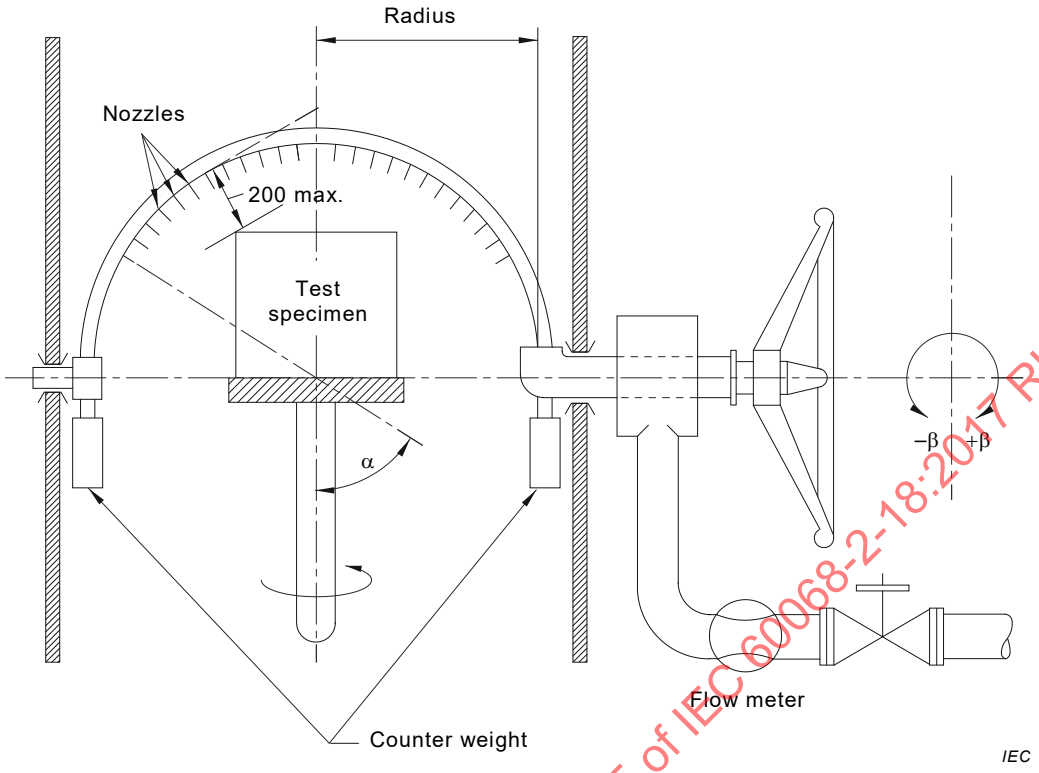
D.2.1.1 Method Rb 1.1: oscillating tube

Depending on the chosen severity and of the type of oscillating tube:

- the oscillating tube is provided with straight flow nozzles of 0,4 mm or 0,8 mm in diameter at 50-mm centre-to-centre distances.

  The nozzles are positioned over an angle (α) of 60° or 90° on either side of the centre point of the oscillating tube. The mean flow rate through each nozzle is 0,07 l/min or 0,6 l/min;
- the oscillating tube should be oscillated – at a rate of 30°/s – through an angle (β) of 60° or 180° (approximately) on either side of the vertical centre plane;
- the support is placed at the centre of the semicircle of the tube and should be movable up and down so that all relevant parts of the specimen are wetted during the test;
- the support should be lockable in one defined position or be adjustable in two positions located through a horizontal angle of 90°;
- the support should not be perforated (for example, for testing of IPX3 of IEC 60529) or should be suitably perforated (for example, for testing of IPX4 of IEC 60529);
- the test specimen is mounted on the support at approximately the centre point of the semicircle of the tube.

Figure D.1 shows the principle design of a test apparatus for Rb 1.1.



NOTE 1 The nozzles have a centre-to-centre distance of 50 mm.

NOTE 2 This method does not work well when the spray tube radius exceeds 1 600 mm.

NOTE 3 α is the angle of arc on either side of the vertical of the section of the oscillating tube fitted with nozzles. β is the angle of rotation of the oscillating tube on either side of the vertical.

NOTE 4 This apparatus is commonly in use and is commercially available, but a different test apparatus, including the nozzles, ~~may~~ can be used if it can be demonstrated that the results obtained are identical.

Figure D.1 – Test Rb 1.1, recommended test apparatus for the oscillating tube method

NOTE When testing IPX3 or IPX4 of IEC 60529, the test specimen is placed in one defined position while the tube is oscillated through the specified angles; only for IPX3 the specimen is turned once after 5 min test duration into a second fixed position through a horizontal angle of 90° and the test is then continued for the remaining test duration of 5 min.

For a specified set of measurement conditions, Figure D.2 gives an indication of the distribution of the precipitation intensity that can be expected within a specific test volume (radius of the oscillating tube: 1 000 mm).

D.2.1.2 Method Rb 1.2: spray nozzle

The spray nozzle should be used when larger specimens are to be tested. The moving shield can be in place or removed during the test. When the specimen has to be sprayed from all practicable directions, the shield has to be removed from the spray nozzle (see also Figure D.3).

D.2.2 Method Rb 2: water jet

This test is performed by spraying the specimen from the specified direction with a stream of water from a standard test nozzle. The test specimen should be mounted on a perforated fixture and should preferably be capable of rotation.

For the test, two sizes of nozzles are available having an internal diameter of 6,3 mm and of 12,5 mm. For the small nozzle, the delivery rate should be 12,5 (1 ± 5 %) l/min, which requires a pressure of approximately 30 kPa (0,3 bar) or 75 (1 ± 5 %) l/min requiring approximately 1 000 kPa (10 bar). The larger nozzle should have a delivery rate of 100 (1 ± 5 %) l/min requiring a pressure of approximately 100 kPa (1 bar) (see also Figure D.4).

D.2.3 Method Rb 3: fan jet nozzle

The test is made by spraying the specimen with a stream of high-pressure and high-temperature water from the test nozzle shown in Figures D.5, D.6 and D.7.

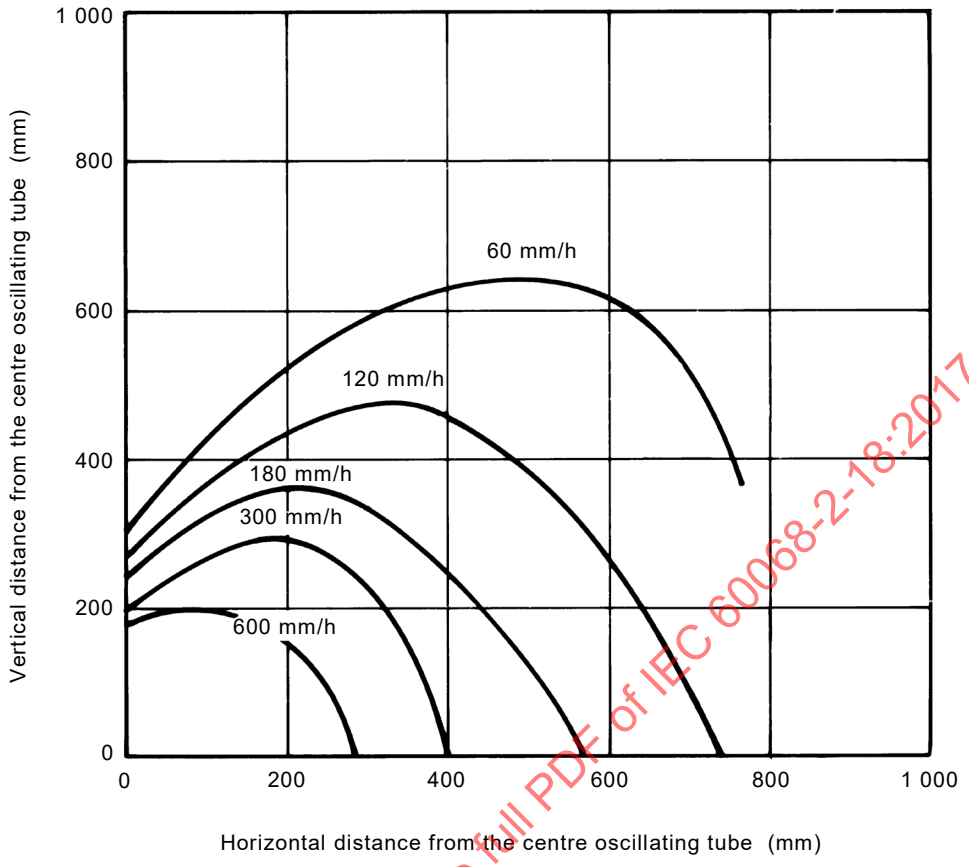
The set-up for measuring the impact force of the water jet is given in Figure D.8 and the distribution force shall be verified at upper and lower limits of distance tolerance range (see Figure D.9).

During the test a) or b) of the enclosure, the water temperature shall be (80 ± 5) °C.

a) For small enclosures (largest dimension less than 250 mm), the enclosure shall be mounted on the turntable shown in Figure D.10.

b) For large enclosures (largest dimension greater than or equal to 250 mm), the enclosure shall be mounted as per its intended use. The entire exposed surface area of the enclosure shall be subjected to the spray at some point during the test procedure. The enclosure shall be sprayed from all practical directions covering the entire surface area and the spray shall be, as far as possible, perpendicular to the sprayed surface.

Dimensions in millimetres

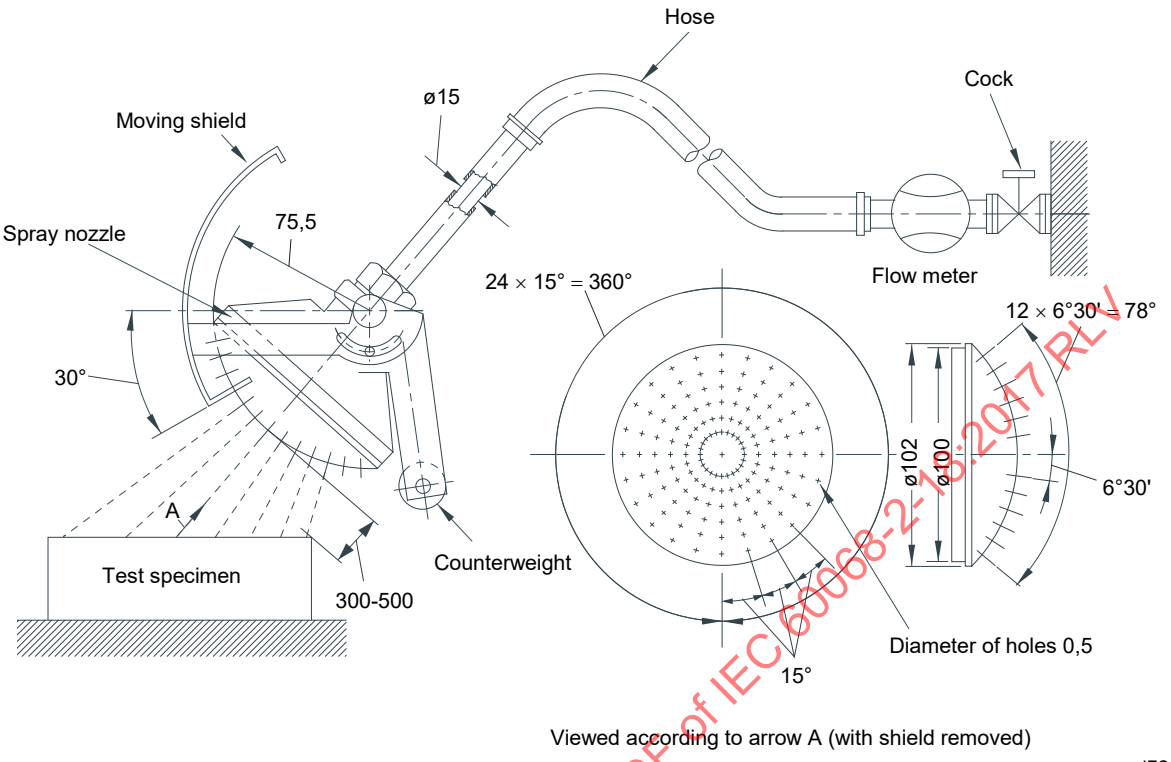


Measurement conditions

Nozzle diameter:	0,4 mm
Radius of oscillating tube:	1 000 mm
Water pressure at inlet:	80 kPa which corresponds to a water flow of approximately 0,1 l/min per nozzle
Nozzle angle:	α = 60°
Tube oscillating angle:	β = 60°
Measurement time:	20 min

Figure D.2 – Distribution of mean value of precipitation intensity in the oscillating tube area ~~for the above-specified measurement conditions~~

Linear dimensions in millimetres



Key

121 holes of ø0,5

1 hole at the centre

2 inner circles of 12 holes at 30° pitch

4 outer circles of 24 holes at 15° pitch

Moving shield – aluminium

Spray nozzle – brass

NOTE This apparatus is commonly in use and is commercially available, but a different test apparatus ~~may~~ can be used if it can be demonstrated that the results obtained are identical.

Figure D.3 – Test Rb 1.2, recommended test apparatus for the spray nozzle method

Linear dimensions in millimetres

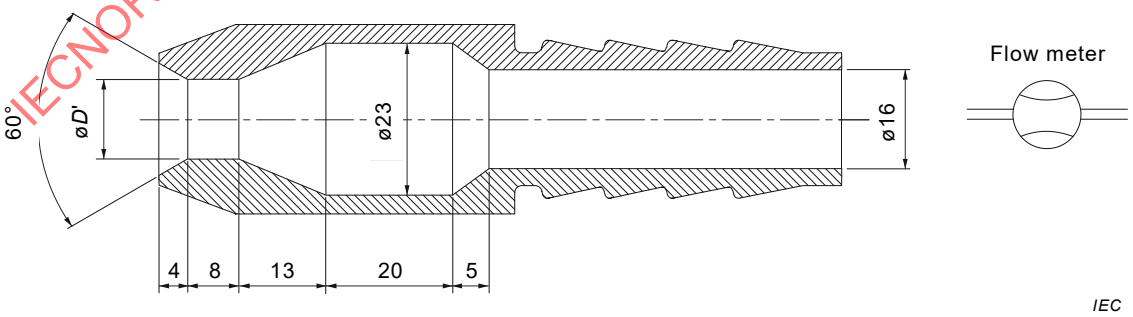
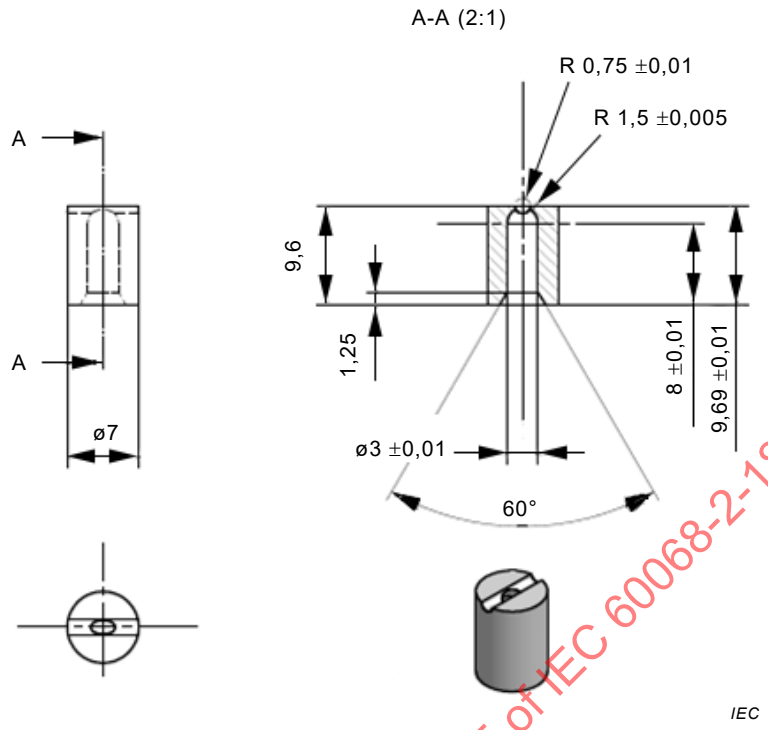


Figure D.4 – Standard test nozzle for the water jet method (hose nozzle)

Dimensions in millimetres



NOTE The dimension 9,69 ± 0,01 refers to the centre of the radius R 0,75 ± 0,01.

Figure D.5 – Standard test nozzle for the fan jet method

Dimensions in millimetres

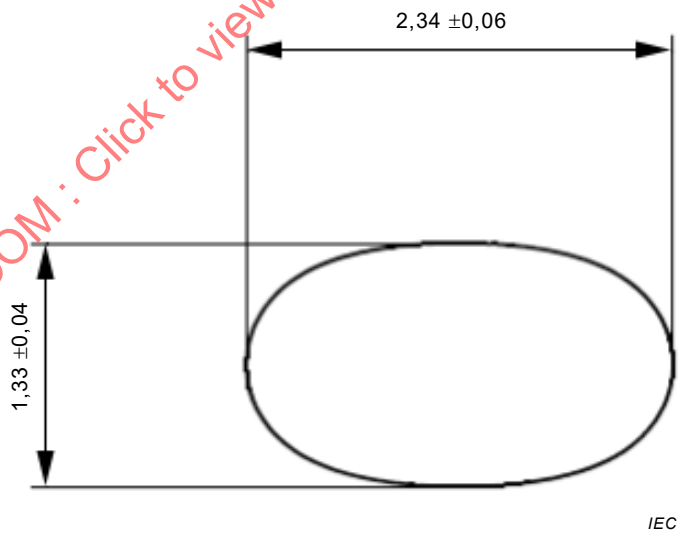
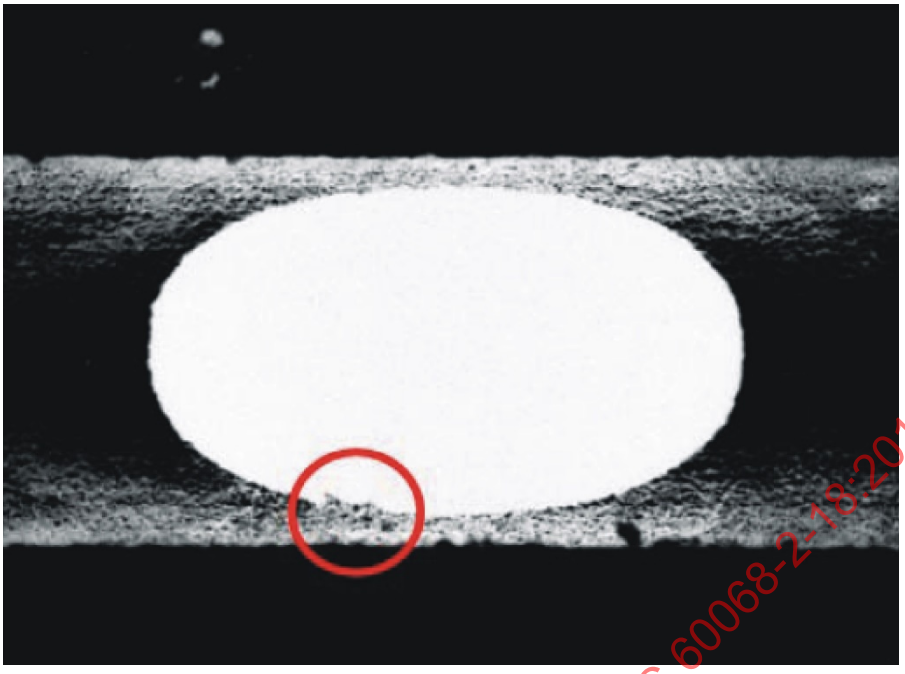
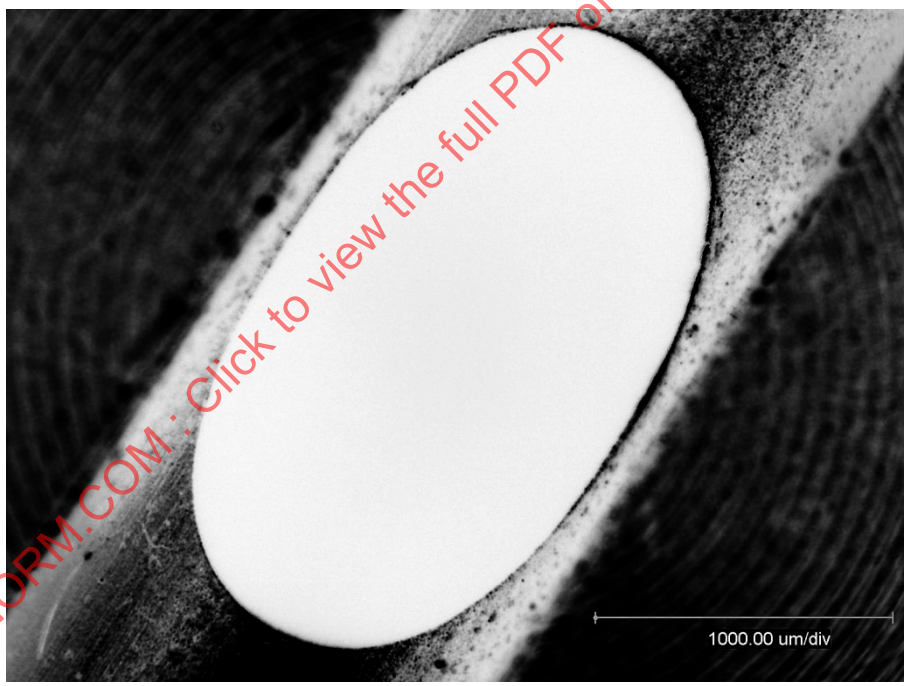


Figure D.6 – Fan jet nozzle resulting dimensions of spraying hole for checking purpose



Bad surface finish

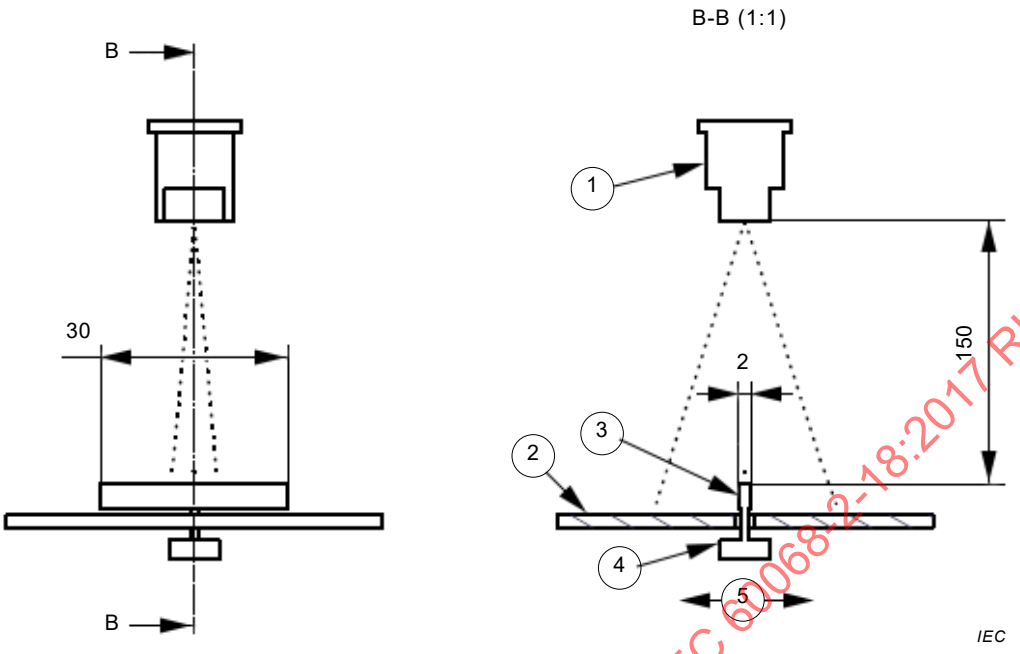


Good surface finish

IEC

Figure D.7 – Example of different quality achievements of the surface finish of the fan jet nozzle

Dimensions in millimetres



Key

1 fan jet nozzle: adjustment of the flow – rate between (15 ± 1) l/min to reach a distribution impact force of 0,9 N to 1,2 N. Water temperature during verification (20 ± 5) °C.

2 cover plate

3 impact plate 2 mm × 30 mm

4 force sensor

5 distribution forces directions (see also Figure D.9)

Figure D.8 – Set-up for measuring the impact force of the water jet for determining the protection against high-pressure and high-temperature water jets

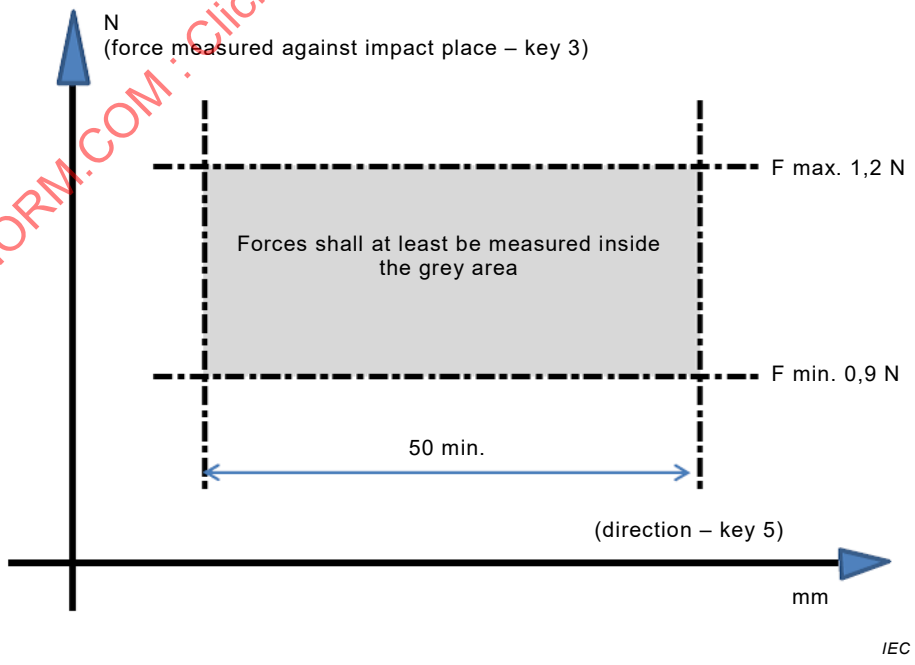
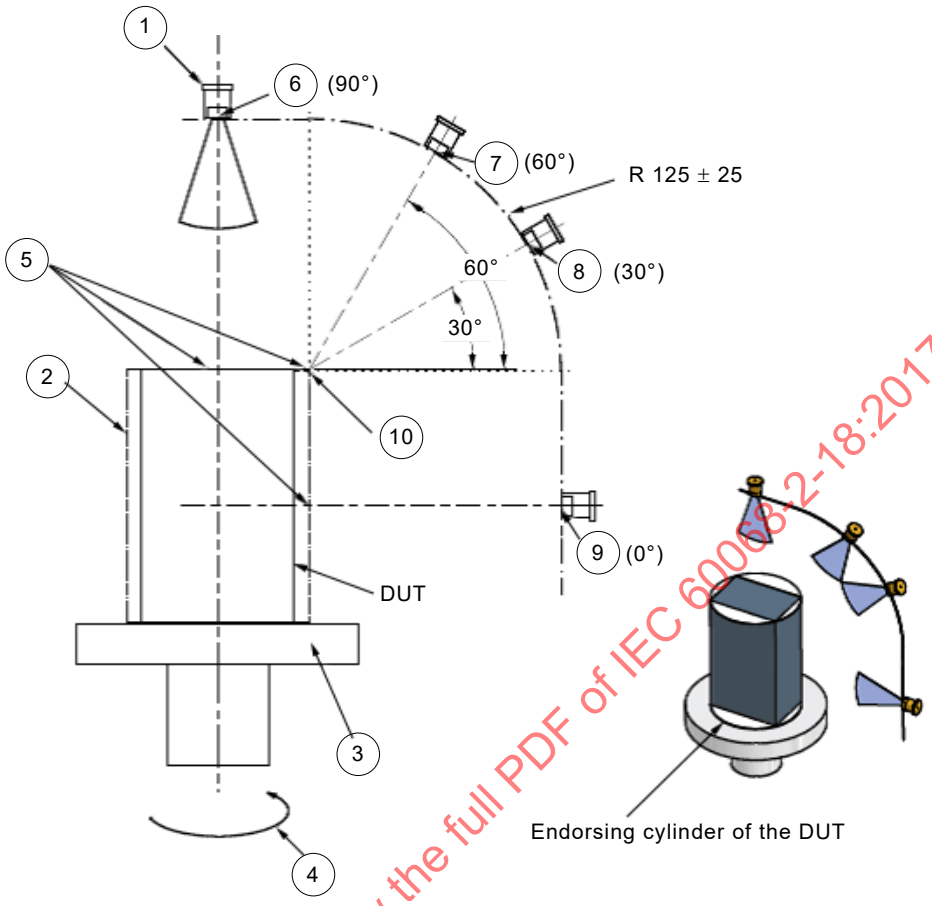


Figure D.9 – Impact force distribution

Dimensions in millimetres



Key

1	fan jet nozzle	6	position 1 of the nozzle (90°)
2	endorsing cylinder for DUT	7	position 2 of the nozzle (60°)
3	holder (rotating table)	8	position 3 of the nozzle (30°)
4	swivel axis (axis of rotation)	9	position 4 of the nozzle (0°)
5	reference point for 0°, for 30° and 60°, then for 90° versus the endorsing cylinder for DUT	10	centre point of circle R 125 mm to locate nozzles

Figure D.10 – Test setup for determining the protection against high-pressure and high-temperature water jet for small enclosures

Annex E
(informative)

Guidance for test Rc

E.1 General

Test Rc: Immersion comprises two test methods

Method Rc 1: Water tank and method Rc 2: Pressurized water chamber are both applicable for products which, during transportation or in service, may be subjected to immersion.

E.2 Example of test apparatus

E.2.1 Method Rc 1: water tank

The required test apparatus should include a water container which can achieve a covering depth of 1 m (or other required depths) of water over the uppermost point of the specimen and maintain the test specimen at that depth.

A water soluble dye such as fluorescein may be added to the water to aid locating and analysing water leaks. Manufacturer's instructions should be followed.

E.2.2 Method Rc 2: pressurized water chamber

The required test apparatus is a positive pressure chamber containing a water tank capable of holding the specimen and covering it with water.

A water soluble dye such as fluorescein may be added to the water to aid locating and analysing water leaks. The manufacturer's instructions should be followed.

E.3 Verification of test apparatus

This is done by measuring the depth of immersion for test Rc 1, or the water pressure for test Rc 2. Measurements of resistivity and pH values are made if required by the relevant specification.

Bibliography

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60068-2-18

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

ENVIRONMENTAL TESTING –

Part 2-18: Tests – Test R and guidance: Water

FOREWORD

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International Standard IEC 60068-2-18 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test.

This third edition cancels and replaces the second edition published in 2000. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) addition of the new test method Rb 3.

The text of this standard is based on the following documents:

FDIS	Report on voting
104/719/FDIS	104/722/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

A number of water tests are described in other IEC publications. Some of them are well established, for example, the test for classification of the second characteristic numeral of the IP Code, of IEC 60529.

This document incorporates the majority of the most widely used tests, as well as making available further methods and increasing the number of severities.

ENVIRONMENTAL TESTING –

Part 2-18: Tests – Test R and guidance: Water

1 Scope

This part of IEC 60068 provides methods of test applicable to products which, during transportation, storage or in service, can be subjected to falling water drops, impacting water, immersion or high pressure water impact. The primary purpose of water tests is to verify the ability of enclosures, covers and seals to maintain components and equipment in good working order after and, when necessary, under a standardized drop field or immersion in water.

These tests are not corrosion tests and cannot be considered and used as such.

Established water tests in other standards are not intended to simulate natural rainfall and their quoted intensities are too high to be adopted for that purpose. Therefore, in addition to the high-intensity severities, test R includes an artificial rain test based upon natural conditions but not taking into account high wind speeds generally associated with natural rain.

Guidance is given on the applicability of the tests and the severities to be selected.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardisation at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
rain
precipitation in the form of water drops

Note 1 to entry: Both the amount that falls and the actual falling action of the water drops are often called rainfall.

3.2
drizzle
precipitation in the form of very small, numerous and uniformly dispersed water drops that may appear to float while following air currents

3.3
raindrop
drop of water having a diameter greater than 0,5 mm falling through the atmosphere

3.4
drizzledrop
drop of water having a diameter of 0,2 mm to 0,5 mm falling through the atmosphere

3.5
R
rainfall or drizzle intensity
amount that falls per unit of time

Note 1 to entry: Rainfall intensity (R) is given in millimetres per hour (mm/h) where 1 l/(m^2 · h) equals 1 mm/h.

3.6
***D*$_{50}$**
median volume diameter
diameter of a drop whose size is such that 50 % of the volume of water reaching the ground is comprised of smaller (or larger) drops

Note 1 to entry: Median volume diameter can be calculated using the formula:

D_{50} = 1,21 $R^{0,19}$ (mm)

where R is the rainfall intensity (see 3.5).

4 Survey of water tests

4.1 General

This survey indicates the general structure of the various tests included in this document.

The structuring of the different tests is given in Figure 1.

4.2 Description of tests R: water

The water tests are structured into three groups.

- Ra: "falling drops" which, in principle, is a test with artificial rain and a test simulating falling drops from condensation or leakage.
- Rb: "impacting water" where water jets impinge upon the test specimen with a certain force and may assume any angle towards the test specimen.
- Rc: "immersion" where the test specimen is immersed in water to specified depths or equivalent pressures.

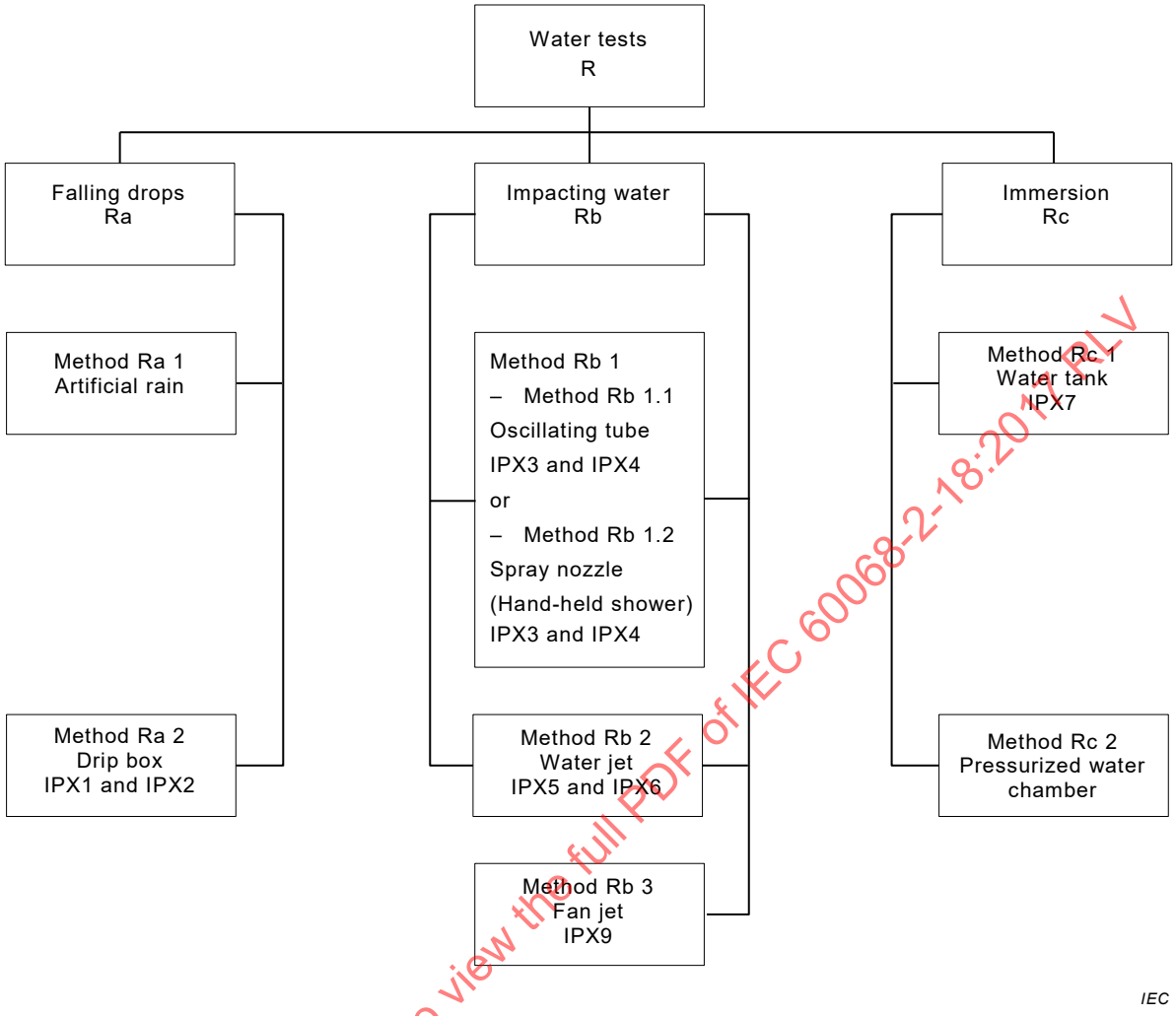


Figure 1 – Structuring of test methods and equivalence with the IP Code of IEC 60529

5 Test Ra: falling drops

5.1 Object

This test is applicable to products which, during transportation, storage or in service may be exposed to vertical falling drops, the origin of these being, for example, natural rain, seepage or condensation. It shall be clearly stated in the relevant specification whether a product hereinafter referred to as a specimen has to function during testing or merely to survive conditions of falling drops. In either case, the relevant specification shall always specify the acceptable tolerances in performance.

5.2 Method Ra 1: artificial rain

5.2.1 General description of the test

The test specimen is mounted on an appropriate fixture or base support. It is then subjected to falling waterdrops, which simulate natural rain.

The basic requirements for the test apparatus are as follows.

- Drop-generating nozzle or nozzles (see C.2.1 and Figure C.1).
- Fixture for the specimen

The fixture shall simulate as far as possible the mounting of the specimen when in service; for example, for wall-mounted equipment the fixture shall simulate a wall.

- Support of the test specimen

  The support shall have a base area which is smaller than the base area of the specimen. The support shall be either a turntable which has a rotation speed of 1 r/min and the eccentricity (distance between turntable axis and specimen axis) is approximately 100 mm, or a table which does not turn. The support shall be able to hold the specimen in any test position and, if necessary, be tilted to a maximum of 90° from the vertical plane.

- Water supply with controls

  The water used for the test shall be fresh tap water of good quality. In order to avoid clogging of the nozzles, the water shall be filtered and may be demineralized. Details of the characteristics of the water are given in Annex A. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

5.2.2 Severities

The severities, as indicated by intensity (and associated drop-size distribution), duration and tilt angle of specimen shall be specified in the relevant specification. The values shall be selected from those given below, a longer duration may be specified in the relevant specification. Wind-driven rain is not simulated by this test as the wind velocity is not a parameter of test.

- Intensity, mm/h and (associated drop-size distribution, mm):

  10 ± 5 (D_{50} = 1,9 ± 0,2); 100 ± 20 (D_{50} = 2,9 ± 0,3); 400 ± 50 (D_{50} = 3,8 ± 0,4).

- Duration, min:

  10, 30, 60, 120.

- Tilt angle α, degrees:

  0, 15, 30, 60, 90.

5.2.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

5.2.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All features of the specimen likely to affect the test result, for example surface treatment, enclosures, covers or seals, shall be inspected to ensure that the instructions of the relevant specification have been followed.

5.2.5 Testing

The specimen shall be mounted on the support either

- in its normal operating position, as specified in the relevant specification; or
- tilted from the normal operating position and provision made for rotating the specimen in a plane perpendicular to the tilted axis. The rotation may be achieved by a rotating support table or by repositioning the specimen at regular intervals during the test. Alternatively, the specimen can be oscillated through an arc of 270° to avoid the need for slip-ring contacts.

The relevant specification shall specify the tilt angle or angles, the face or faces to be exposed to the drop field and the duration of exposure for each side, or whether the specimen shall be continuously rotated or oscillated through 270°. See also Figure 2.

The specimen shall be subjected to artificial rain with severities selected from 5.2.2 and specified in the relevant specification.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing the specimen in the energized condition.

5.2.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

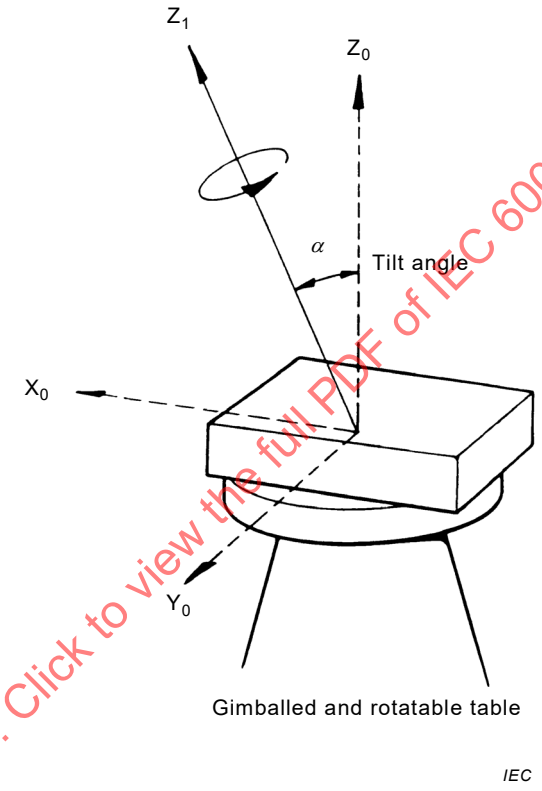


Figure 2 – Test Ra, definitions of angles and axes

5.2.7 Final measurements

The specimen shall be examined for ingress of water and submitted to visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water should be quantified if possible and reported.

5.2.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Severities*	5.2.2
b) Preconditioning	5.2.3
c) Initial measurements*	5.2.4
d) Mounting of specimen*	5.2.5
e) Specimen position or positions during testing*	5.2.5
f) State of the specimen during testing*	5.2.5
g) Intermediate measurements	5.2.5
h) Recovery	5.2.6
i) Final measurements*	5.2.7

5.3 Method Ra 2: drip box

5.3.1 General description of the test

The test specimen is mounted on an appropriate fixture placed under the drip box. The test specimen is subjected to water drops, which simulate water falling as a result of condensation or leakage.

The basic requirements for the test apparatus are as follows:

- Drip box

  The drip box shall normally have a base area larger than the projected area of the specimen. If the base of the drip box is smaller than that of the specimen under test, the latter may be divided into several sections, the area of each section being large enough to be covered by the dripping water. The test is continued until the whole area of the specimen has been sprinkled for the specified time. The drip box shall be capable of providing a uniform drop field with a precipitation of the specified intensity.

  The grid pattern of the nozzles shall be 20 mm (for IP Code tests) or 25 mm. The distance from the bottom of the drip box to the highest point of the specimen shall be adjustable to either 0,2 m or 2 m. A suitable drip-box layout is described in C.2.2 and in Figure C.2.

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting of the specimen when in service; for example, for wall-mounted equipment the fixture shall simulate a wall.

- Support of the test specimen

  The support shall have a base area which is smaller than the base area of the specimen. The support shall either be a turntable which has a rotation speed of 1 r/min and an eccentricity (distance between turntable axis and specimen axis) of approximately 100 mm, or a table which does not turn. The support shall be able to hold the specimen in any test position and, if necessary, be tilted to a maximum of 45° from the vertical plane.

- Water supply with controls

  The water used for the test shall be fresh tap water of good quality. In order to avoid clogging of the nozzles, the water shall be filtered and may be demineralized. Details of the characteristics of the water are given in annex A. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

5.3.2 Severities

The severities, as indicated by drop falling height, tilt angle of specimen, duration and water intensity, shall be specified in the relevant specification. The values shall be selected from the following:

- Drop falling height, (h), m: 0,2; 2
- Tilt angle α, degrees: 0; 15; 30; 45
- Duration, min: 3; 10; 30; 60

NOTE The 3 min duration applies only when a tilt angle of 0° is specified.

- Water intensity, mm/h: $60\ ^{+30}_{0}$; $180\ ^{+30}_{0}$

5.3.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

5.3.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All the features of the specimen likely to affect the test result, for example, surface treatment, covers or seals, shall be inspected to ensure that the instructions of the relevant specification have been followed.

5.3.5 Testing

The specimen shall be mounted on the support in its normal operating position under the drip box. The support shall then either be rotated or tilted to the specified angle in each of the four positions of tilt. These positions are on either side of the vertical in two mutually perpendicular planes. If a special mounting condition is required (for example, wall or ceiling), it shall be specified in the relevant specification.

In both cases, the test shall be carried out in the conditions specified in 5.3.1 and the severity selected from 5.3.2.

In the case of tilted support, the duration shall be divided equally between the four positions.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made. Appropriate safety precautions shall be taken when testing the specimen in the energized condition.

5.3.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

5.3.7 Final measurements

The specimen shall be examined for ingress of water and submitted to visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water should be quantified if possible and reported.

5.3.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

Subclause

a) Severities* 5.3.2
b) Preconditioning 5.3.3
c) Initial measurements* 5.3.4
d) Mounting of specimen* 5.3.5
e) Specimen position or positions during testing* 5.3.5
f) State of the specimen during testing* 5.3.5
g) Intermediate measurements 5.3.5
h) Recovery 5.3.6
i) Final measurements* 5.3.7

6 Test Rb: impacting water

6.1 Object

This test is applicable to products which, during transportation, storage or in service may be subjected to impacting water. The origin for this can be water from cloudbursts, heavy driving rain, sprinkler systems, pressure cleaning, spray from wheels, sluicing or breaking seas. The relevant specification should clearly specify whether a product tested separately, hereinafter referred to as a specimen, has to function during testing or merely survive conditions of impacting water. In either case, the relevant specification shall always specify the acceptable tolerances in performance.

6.2 Method Rb 1: oscillating tube and spray nozzle

6.2.1 General description of the test

The tests are intended to simulate spraying or splashing water, for example, the results of water action of sprinkler systems. Guidance for this test is given in Annex D. The test is made using either the test device described in Figure D.1 or the test device described in Figure D.3 in accordance with the relevant specification. The test specimen is mounted on an appropriate fixture and is subjected to impacting water generated from either a semicircular tube or a spray nozzle.

6.2.2 Method Rb 1.1: oscillating tube

6.2.2.1 Test apparatus

The basic requirements for the test apparatus are as follows.

- Oscillating tubes

  Three types of tube may be used. The tube shall be provided with nozzles of either 0,4 mm diameter for type 1 and type 2 or 0,8 mm diameter for type 3, at a 50 mm centre-to-centre distance over an arc of 60° on either side of the vertical for type 1 or 90° on either side of the vertical for type 2 and type 3. The tube shall be able to oscillate through an angle of 60° on either side of the vertical for type 1 or 180° on either side of the vertical for type 2 and type 3.

  The maximum acceptable radius of the oscillating tubes, type 1 and type 2 is 1 600 mm. For oscillating tube type 3, the radius shall not exceed 800 mm. The radius shall be selected in such a way that the clearance between the specimen and the inside of the tube does not exceed 200 mm.

  The relationship between the number of nozzles, each having a mean flow rate of 0,07 l/min or 0,6 l/min and the total flow rate is given in Table 2.

  A suitable apparatus is shown in Figure D.1.

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting structure to be used in the real use of products; for example, for wall-mounted equipment, the fixture shall simulate a wall.

- Support for the specimen

  The support for the specimen shall not be perforated for type 1 and shall be suitably perforated for type 2 and type 3.

- Water supply with controls

  The water used for the test shall be fresh tap water of good quality. In order to avoid clogging of the nozzles, the water shall be filtered and may be demineralized. Details of the characteristics of the water are given in Annex A. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

6.2.2.2 Severities

The severities as indicated by the nozzle angle, water flow rate per hole, tube oscillating angle and duration shall be specified in the relevant specification. The values shall be selected from those given below.

Any combination of water test severities can be chosen independently. In this case, such a combination shall be stated in the relevant specification.

Type 1 tube

- Nozzle angle α, degrees ±60
- Water flow per hole, l/min 0,07 (1 ± 5 %)
- Tube oscillating angle β,degrees ±60
- Duration, min 2 × 5

Type 2 tube

- Nozzle angle α, degrees ±90
- Water flow per hole, l/min 0,07 (1 ± 5 %)
- Tube oscillating angle, β degrees ±180 (approximately)
- Duration, min 10, 30, 60

Type 3 tube

- Nozzle angle α, degrees ±90
- Water flow per hole, l/min 0,6 ± 0,03
- Tube oscillating angle, β degrees ±180 (approximately)
- Duration, min 2 × 5

In some cases, the relevant specification may specify a longer duration.

6.2.2.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

6.2.2.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All features of the specimen likely to affect the test results, such as

surface treatment, covers or sealing, shall be inspected to ensure that the instructions of the relevant specification have been followed.

6.2.2.5 Testing

Three types are described:

Type 1:

The specimen to be tested shall be attached to a fixture, if specified, and shall be placed on the support in its normal operational attitude. For this test, the support shall not be perforated. An oscillating tube as described in Figure D.1, with nozzles over an arc of 60° on either side of vertical shall be chosen having a radius to meet the dimensional requirements of the test specimen. The maximum radius is 1 600 mm. If the test specimen is too large, the spray nozzle test shall be used. The tube is caused to oscillate through an angle of 60° on either side of vertical. The time taken for one complete oscillation from +60° to -60° to +60° shall be approximately 4 s.

Water flow shall be set to the required rate given in Table 1.

The duration of the test shall be 5 min.

The test specimen shall be turned through a horizontal angle of 90° and the test shall be continued for a further 5 min.

If it is not possible to wet all parts of the test specimen, the support shall be moved up and down or the spray nozzle test shall be used.

The relevant specification shall state whether the specimen shall be operated during the test and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing in the energized condition.

Table 1 – Oscillating tube – Relationship of number of nozzles and total water flow to tube radius

	Type 1		Type 2		Type 3	
Tube radius R	Number of open nozzles	Total water flow	Number of open nozzles	Total water flow	Number of open nozzles	Total water flow
mm	N[a]	l/min	N[a]	l/min	N[a]	l/min
200	8	0,56	12	0,84	12	7,2
400	16	1,1	25	1,8	25	15,0
600	25	1,8	37	2,6	37	22,2
800	33	2,3	50	3,5	50	30,0
1 000	41	2,9	62	4,3	–	–
1 200	50	3,5	75	5,3	–	–
1 400	58	4,1	87	6,1	–	–
1 600	67	4,7	100	7,0	–	–

[a] Depending on the actual arrangement of nozzle centres at the specified distance, the number of open nozzles N may be increased by 1.

Type 2:

The test is the same as for type 1 with the following differences:

- the support shall be perforated unless specified otherwise in the relevant specification;
- the oscillating tube shall have nozzles over an arc of 90° on either side of vertical;
- the tube shall oscillate through an angle of almost 360°, 180° on either side of vertical;
- the time taken for one complete oscillation, from +180° to –180° to +180° shall be approximately 12 s;
- the test duration shall be selected from 6.2.2.2;
- the test specimen is not turned through a horizontal angle of 90° and the test is not continued for any further time;
- the relevant specification shall specify the orientation if it affects the severity of the test.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing in the energized condition.

Type 3:

The test is the same as for type 2 with the following differences:

- the test duration is 2 × 5 min; that is after 5 min of test, the specimen is turned through a horizontal angle of 90° and the test is continued for a further 5 min.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing in the energized condition.

6.2.2.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

6.2.2.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

6.2.2.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Severities*	6.2.2.2
b) Preconditioning	6.2.2.3
c) Initial measurements*	6.2.2.4
d) Mounting of specimen*	6.2.2.5
e) Specimen position or positions during testing*	6.2.2.5
f) State of the specimen during testing*	6.2.2.5
g) Intermediate measurements	6.2.2.5
h) Recovery	6.2.2.6
i) Final measurements*	6.2.2.7

6.2.3 Method Rb 1.2: spray nozzle

6.2.3.1 Test apparatus

The basic requirements for the test apparatus are as follows.

- Spray nozzle (also known as hand-held shower)

  A spray nozzle with a spray cone of 78° and a moving shield which is able to limit the upper part of the spray cone to 30° from the horizontal. The shield may be removed as specified. The spray nozzle shall have a delivery rate of 10 l/min ± 5 % which necessitates a water pressure of 50 kPa to 150 kPa (0,5 bar to 1,5 bar) (see Figure D.3).

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting structure to be used in real use of products; for example, for wall-mounted equipment, the fixture shall simulate a wall.

- Support for the specimen

  The support for the specimen shall have a base area which is smaller than the base area of the specimen or be suitably perforated.

- Water supply with controls

  The water supply shall be capable of delivering, in a stable flow, at least 10 l/min. The water used for the test shall be fresh tap water of good quality. In order to avoid clogging of the holes, the water shall be filtered and may be demineralized. Details of the characteristics of the water are given in Annex A. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

6.2.3.2 Severities

The specimen surfaces to be sprayed, if not all, shall be specified. The severities as indicated by the use of the shield or not and the test duration shall be specified in the relevant specification. The severities shall be selected from those given below.

- Moving shield: in use, removed.
- Test duration, min/m^2 test surface, calculated with a tolerance of ±10 % (subject to a minimum duration, min)

  1 (5); 3 (15); 6 (30).

In some cases, the relevant specification may specify a longer duration.

6.2.3.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

6.2.3.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All features of the specimen likely to affect the test result, such as surface treatment, covers or sealing, shall be inspected to ensure that the instructions of the relevant specification have been followed.

6.2.3.5 Testing

The specimen shall be mounted as described in the oscillating tube test procedure (6.2.2.5 type 1 or type 2). The water pressure shall be adjusted to give a delivery rate of 10 (1 ± 5 %) l/min. It shall be kept constant throughout the test. The specified surfaces shall be sprayed for the specified duration and from a distance of (0,4 ± 0,1) m. When the spray nozzle is used as an alternative to the oscillating tube type 2, the moving shield shall be removed and the spray shall be applied at ±180° from vertical.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing in the energized condition.

6.2.3.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

6.2.3.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

6.2.3.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Severities*	6.2.3.2
b) Preconditioning	6.2.3.3
c) Initial measurements*	6.2.3.4
d) Mounting of specimen*	6.2.3.5
e) Specimen position or positions during testing*	6.2.3.5
f) State of the specimen during testing*	6.2.3.5
g) Intermediate measurements	6.2.3.5
h) Recovery	6.2.3.6
i) Final measurements*	6.2.3.7

6.3 Method Rb 2: water jet

6.3.1 General description of the test

The test specimen is mounted on a fixture. The test specimen is subjected to a water jet which should simulate wheel spray, or breaking seas. The standard test nozzle is described in D.2.2 and Figure D.4.

The basic requirements for the test apparatus are:

- Hose nozzle

  The hose nozzle shall give a solid water jet and have a free diameter of 6,3 mm and 12,5 mm for the small and large nozzle respectively (see Figure D.4).

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting structure to be used in the real use of products; for example, for wall-mounted equipment, the fixture shall simulate a wall.

  The fixture for the specimen shall have a base area which is smaller than the base area of the specimen or be suitably perforated.

  The fixture shall have a sufficient strength and stability to withstand the hydrodynamic effect of the water jet.

- Water supply with controls

  The water supply shall be fresh tap water of good quality and shall be capable of delivering at least 100 l/min. The water pressure should be at least 100 kPa at this flow or 1 000 kPa when using the small nozzle. During the test, the water temperature shall not differ by more than 5 K from the temperature of the specimen under test. If the water temperature is more than 5 K below the temperature of the specimen, a pressure balance shall be provided for the specimen.

6.3.2 Severities

The severities as indicated by the choice of hose nozzle size, flow rate and test duration shall be specified in the relevant specification. The values shall be selected from those given below:

6,3 mm nozzle

- Flow rate, l/min (and corresponding approximate supply pressure, kPa)

  75 (1 ± 5 %) (1 000)

- Duration, min/m^2 of the test surface, calculated with a tolerance of ±10 % (subject to a minimum duration, min)

  0,3 (1)

6,3 mm nozzle

- Flow rate, l/min (and corresponding approximate supply pressure, kPa)

  12,5 (1 ± 5 %) (30)
- Duration, min/m^2 of the test surface, calculated with a tolerance of ±10 % (subject to a minimum duration, min)

  1 (3); 3 (10)

12,5 mm nozzle

- Flow rate, l/min (and corresponding approximate supply pressure, kPa)

  100 (1 ± 5 %) (100)
- Duration, min/m^2 of the test surface, calculated with a tolerance of ±10 % (subject to a minimum duration, min)

  1 (3); 3 (10); 10 (30)

6.3.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

6.3.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All features of the specimen likely to affect the sealing shall be inspected to ensure that the instructions of the relevant specification have been followed.

6.3.5 Testing

The specimen shall be mounted on the fixture in its normal operating position.

The distance from the nozzle to the specimen shall be 2,5 m ± 0,5 m. This distance may be reduced if necessary to ensure proper wetting when spraying upwards. At a distance of 2,5 m from the nozzle, the substantial part of the water jet shall be within a circle of 40 mm for the 6,3 nozzle and 120 mm for the 12,5 mm nozzle.

Unless otherwise specified in the relevant specification, the specimen shall be sluiced on all faces from all practicable directions with a stream of water from a standard test nozzle as shown in Figure D.4.

The size of nozzle, flow rate and test duration shall be as specified in the relevant specification, selected from 6.3.2.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing specimens in the energized condition.

6.3.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

6.3.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

6.3.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Severities*	6.3.2
b) Preconditioning	6.3.3
c) Initial measurements*	6.3.4
d) Mounting of specimen*	6.3.5
e) Specimen position or positions during testing*	6.3.5
f) State of the specimen during testing*	6.3.5
g) Intermediate measurements	6.3.5
h) Recovery	6.3.6
i) Final measurements*	6.3.7

6.4 Method Rb 3: fan jet

6.4.1 General description of the test

The test is made by spraying the enclosure with a stream of water from a standard test nozzle as shown in Figures D.7, D.8 and D.9.

The set-up for measuring the impact force of the water jet is given in Figure D.10.

The distribution force shall be verified at upper and lower limits of the distance tolerance range (see Figure D.11).

The basic requirements for the test apparatus are as follows.

- Jet nozzle

  The jet nozzle shall give a water fan jet and have an oval-shaped water stream (see Figure D.5).

- Fixture for the specimen

  The fixture shall simulate as far as possible the mounting structure to be used in the real use of products; for example, for wall-mounted equipment the fixture shall simulate a wall.

  The fixture for the specimen shall have a base area which is smaller than the base area of the specimen or be suitably perforated.

  The fixture shall have a sufficient strength and stability to withstand the hydrodynamic effect of the water jet.

- Turntable

  The turntable shall rotate with a speed of 5 r/min ± 1 r/min.

- Water supply with controls

The water supply shall be fresh tap water of good quality and shall be capable of delivering water at at least 15 l/min and with a water temperature of 80 °C.

6.4.2 Severities

The water pressure shall be adjusted to give a delivery rate of (15 ± 1) l/min and the water temperature shall be (80 ± 5) °C.

a) For small enclosures (largest dimension less than 250 mm), the enclosure shall be mounted on the test device shown in Figure D.10:
   - turntable speed: 5 r/min ± 1 r/min;
   - spray positions: 0°, 30°, 60°, 90°;
   - distance between nozzle and sample under test shall be 125 mm ± 25 mm.

   The test duration is 30 s per position.

b) For large enclosures (largest dimension greater than or equal to 250 mm), the enclosure shall be mounted as per its intended use. The entire exposed surface area of the enclosure shall be subjected to the spray at some point during the test procedure:
   - spray positions: the enclosure shall be sprayed from all practical directions covering the entire surface area and the spray shall be, as far as possible, perpendicular to the sprayed surface.
   - distance between nozzle and sample under test shall be 175 mm ± 25 mm.

The test duration is 1 min/m^2 of the calculated surface area of the enclosure (excluding any mounting surface), with a minimum duration of 3 min.

6.4.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

6.4.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All features of the specimen likely to affect the sealing shall be inspected to ensure that the instructions of the relevant specification have been followed.

6.4.5 Testing

The test method a) or b) in 6.4.2 shall be selected based on the dimensions of the specimen.

The specimen shall be mounted on the fixture in its normal operating position.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken for highly pressurized and high-temperature water spray and when testing specimens in the energized condition.

6.4.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

6.4.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

6.4.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Severities*	6.4.2
b) Preconditioning	6.4.3
c) Initial measurements*	6.4.4
d) Mounting of specimen*	6.4.5
e) Specimen position or positions during testing*	6.4.5
f) State of the specimen during testing*	6.4.5
g) Intermediate measurements	6.4.5
h) Recovery	6.4.6
i) Final measurements*	6.4.7

7 Test Rc: immersion

7.1 Object

This test is applicable to products which are designed to be resistant to ingress of water, and which, during transportation or in service, may be subjected to immersion. It shall be clearly stated in the relevant specification whether a product tested separately, hereinafter referred to as a specimen, has to function during testing or merely to survive conditions of immersion in water. In either case, the relevant specification shall always specify the acceptable tolerances in performance.

Normally, fresh tap water is used. If, however, a test is to be made in sea water, this shall be stated in the relevant specification together with the characteristics of the sea water.

The relevant specification may call for measurements of resistivity and pH values.

7.2 Method Rc 1: water tank

7.2.1 General description

The test specimen is subjected to a specified pressure by immersion in a water tank at a specified depth. After testing, the specimen is examined with respect to ingress of water and checked for possible changes of characteristics.

7.2.2 Severities

The severities indicated by head of water and duration shall be specified in the relevant specification. The values shall be selected from those given below.

- Head of water, m

  0,15; 0,4; 1; 2; 5

  The head of water is defined here as the distance from the surface of the water to the uppermost point of the specimen.

  NOTE The IP classification in IEC 60529 defines the head of water differently.

- Duration, h
  0,5; 2; 24

7.2.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

7.2.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All features of the specimen likely to affect the sealing shall be inspected to ensure that the instructions of the relevant specification have been followed.

7.2.5 Testing

The specimen shall be fixed in the position as specified in the relevant specification and shall be completely immersed in a water tank. A water soluble dye such as fluorescein may be added to the water in order to facilitate indication of leakage.

The specimen shall be subjected to the head-of-water value and for the duration specified in the relevant specification, selected from 7.2.2.

The initial water temperature shall be between the specimen temperature and 5 K lower. The water temperature shall under no circumstances exceed 35 °C.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing the specimen in the energized condition.

7.2.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

7.2.7 Final measurements

The specimen shall be examined for the ingress of water, and submitted to the visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

7.2.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Subclause
a) Composition of sea water if specifed	7.1
b) Resistivity and pH values of water (test apparatus)	7.1, E.1
c) Severities*	7.2.2
d) Preconditioning	7.2.3
e) Initial measurements*	7.2.4
f) Mounting of specimen*	7.2.5
g) State of the specimen during testing*	7.2.5
h) Intermediate measurements	7.2.5
i) Recovery	7.2.6
j) Final measurements*	7.2.7

7.3 Method Rc 2: pressurized water chamber

7.3.1 General description of the test

The test specimen is subjected to a specified pressure by complete immersion in water in a pressurized water chamber. After testing, the specimen is examined for ingress of water and checked for possible changes of characteristics.

7.3.2 Severities

The severities indicated by the pressure in the chamber and the duration shall be specified in the relevant specification. The values shall be selected from those given below.

- Overpressure kPa (equivalent head of water, m):

  20 (2) 50 (5) 100 (10) 200 (20) 500 (50)

  1 000 (100) 2 000 (200) 5 000 (500) 10 000 (1 000)

- Duration: h

  2 24 168

7.3.3 Preconditioning

Preconditioning of the specimen and seals shall be carried out if specified in the relevant specification.

7.3.4 Initial measurements

The specimen shall be submitted to the visual, dimensional and functional checks specified in the relevant specification. All features of the specimen likely to affect the sealing shall be inspected to ensure that the instructions of the relevant specification have been followed.

7.3.5 Testing

The specimen shall be placed in the position as specified in the relevant specification and shall be completely immersed in a pressurized water chamber. A water soluble dye such as fluorescein may be added to the water in order to facilitate indication of leakage.

The specimen shall be subjected to the pressure value and for the duration specified in the relevant specification selected from 7.3.2.

During the test the water shall not differ by more than 5 K from the temperature of the specimen under test. The water temperature shall not exceed 35 °C.

The relevant specification shall state whether the specimen shall be operated during testing and if intermediate measurements shall be made.

Appropriate safety precautions shall be taken when testing the specimen in the energized condition.

7.3.6 Recovery

Unless otherwise required in the relevant specification, the specimen shall be thoroughly dried externally by wiping or by applying low-velocity forced air at room temperature.

7.3.7 Final measurements

The specimen shall be examined for ingress of water, and submitted to the visual, dimensional and functional checks specified in the relevant specification.

Any ingress of water shall be quantified if possible and reported.

7.3.8 Information to be given in the relevant specification

Where this test is included in the relevant specification, the following details shall be given in so far as they are applicable. The relevant specification shall supply information as required in the subclauses listed below, paying particular attention to the items marked with an asterisk (*) as this information is always required.

		Subclause
a)	Composition of sea water if specified	7.1
b)	Resistivity and pH values of water (test apparatus)	7.1, E.3
c)	Severities*	7.3.2
d)	Preconditioning	7.3.3
e)	Initial measurements*	7.3.4
f)	Mounting of specimen*	7.3.5
g)	State of the specimen during testing*	7.3.5
h)	Intermediate measurements	7.3.5
i)	Recovery	7.3.6
j)	Final measurements*	7.3.7

Annex A
(informative)

Water characteristics to be considered when writing the relevant specification

A.1 General

Certain characteristics of the water supply for tests in this document are specified in the test methods, for example, drop size, field intensity, velocity of drops and angle of incidence to the specimen. In addition, there are other characteristics of the water supply which may either affect the proper functioning of the test apparatus or have some direct or indirect influence on the specimen.

For the majority of water tests, it is probable that the water will be drawn from a local mains supply; however, such a supply may vary considerably in pressure, temperature and purity. These features will need to be considered in relation to the purpose of the test, for example ingress into the specimen or change of surface characteristics, and the suitability of the water supply will need to be assessed. If the supply is not suitable, it may be subjected to further processing or, if this is not practicable, an alternative source should be provided.

A.2 Purity

A.2.1 General

Mains water supplies normally contain various impurities which may originate from the source, for example the absorption of minerals during its passage through rivers or, as in the case of chlorination, may have been introduced as a disinfectant by chemical processing.

A.2.2 Effect on test specimen

Water tests on certain kinds of specimen may require electrical measurements to be made on the specimen either during or following the spraying period. The electrical measurements may include surfaces directly exposed to the water or those interior surfaces which have been wetted by the ingress of water through vents or leaks. In these circumstances, it may be necessary to ensure that the water from the test apparatus is non-conducting; this implies the need for distilled or deionized water.

Another feature which may need to be considered is that of corrosion of the specimen by the presence of water. The tests in this document are not intended to produce corrosion but this may occur inadvertently under certain conditions. If corrosion is to be avoided, it may be appropriate to use distilled or deionized water; however, it should be noted that pure water may eventually become contaminated by airborne or surface pollutants.

In any event, the appearance of corrosion products is more likely to occur some time after the water test, rather than during the test itself, when the effects of the chemical or electrochemical action have developed.

A.2.3 Effect on test apparatus

Impurities in the water supply to the test apparatus may result in reduced or erratic water flow. The severity of this effect becomes more important with test apparatus operating at lower water pressures. Test methods of test Ra (falling drops) are particularly susceptible to problems of clogging of the water orifice. Filtration of the water supply or the provision of a demineralized supply may be necessary.

A.2.4 Ingress of water into the specimen

Certain features of the water incident to the specimen which affects the ingress, for example, temperature, droplet size, velocity and angle of incidence, are included in the method of test R. However, the composition of the water itself can also affect the entry into any holes or leaks in the specimen. If water is present at the entrance of a hole the flow through the hole is directly proportional to the difference in pressure across it (usually a result of the temperature difference induced by the cooler water) and inversely proportional to the viscosity. The surface tension of the water opposes the flow by reducing the pressure difference and will prevent any flow through very small holes.

Some approximate values of these characteristics of water are given in Table A.1.

A.3 Water quality for tests R

A.3.1 Test Ra: falling drops

The water for these tests should be fresh tap water of good quality. In order to avoid clogging of the nozzles, the water should be filtered and may be demineralized.

Demineralized or distilled water should have a pH value of 6,5 to 7,2 and a resistivity of not less than 500 Ωm.

A.3.2 Test Rb: impacting water

The water for these tests should be fresh tap water of good quality. In order to avoid clogging of the nozzles the water should be filtered and may be demineralized.

A.3.3 Test Rc: immersion

The water for these tests is normally fresh tap water but can be sea water. The water temperature should be (25 ± 10) °C. A water soluble dye such as fluorescein may be added to the water in order to facilitate indication of leakage.

Table A.1 – Typical characteristics of water with approximate values

Relative dielectric constant:	Pure water	80 at 25 °C
Resistivity:	Very pure water	200 000 Ωm
	Deionized water	500 Ωm to 5 000 Ωm
	Mains supply	2,5 Ωm
Surface tension at 20 °C		73×10^{-5} N/cm
Surface tension at 20 °C	With 0,1 g/l wetting agent	43×10^{-5} N/cm
Surface tension at 20 °C	With 0,5 g/l wetting agent	30×10^{-5} N/cm

Annex B
(informative)

General guidance

B.1 General

This document includes a range of water tests either as a field of water drops in air (tests Ra and Rb) or as a homogeneous mass of liquid (test Rc) which may be used to determine their effect on products. The tests are intended to embrace all situations where water in liquid form is a part of the micro-climate surrounding a product, for example, rain, drizzle, hosing, immersion, but excluding erosion resulting from high-velocity water drops.

In the first instance, the effect of interest of a water test is either that of ingress into an enclosure or of a change in the surface characteristics of the product, for example, the lowering of flash-over voltage of electrical isolators. In general, the criterion of success during or following exposure to a water test will depend on the nature of the product and shall be specified in the relevant specification. For certain products, it may be essential that no water penetrates its protective enclosure, while for other products some water penetration may be allowed. During the product design, it is probable that the degree of protection required of the enclosure will depend on the sensitivity to water of the enclosed parts, although the enclosure may serve a variety of purposes beyond that of protection from water.

Appropriate safety precautions should be taken when testing the specimen in the energized condition.

B.2 Factors affecting the test severity

The factors which contribute to the severity of the test are as follows:

a) intensity of rain or water drop field;
b) velocity of water drops;
c) tilt angle of water drop field to specimen;
d) water pressure (test Rc);
e) temperature difference between water and specimen;
f) water quality.

Annex C
(informative)

Guidance for test Ra

C.1 General

Test Ra: falling drops, comprises two test methods.

Method Ra 1: artificial rain, is applicable for products which may be placed outdoors and unprotected from natural rain.

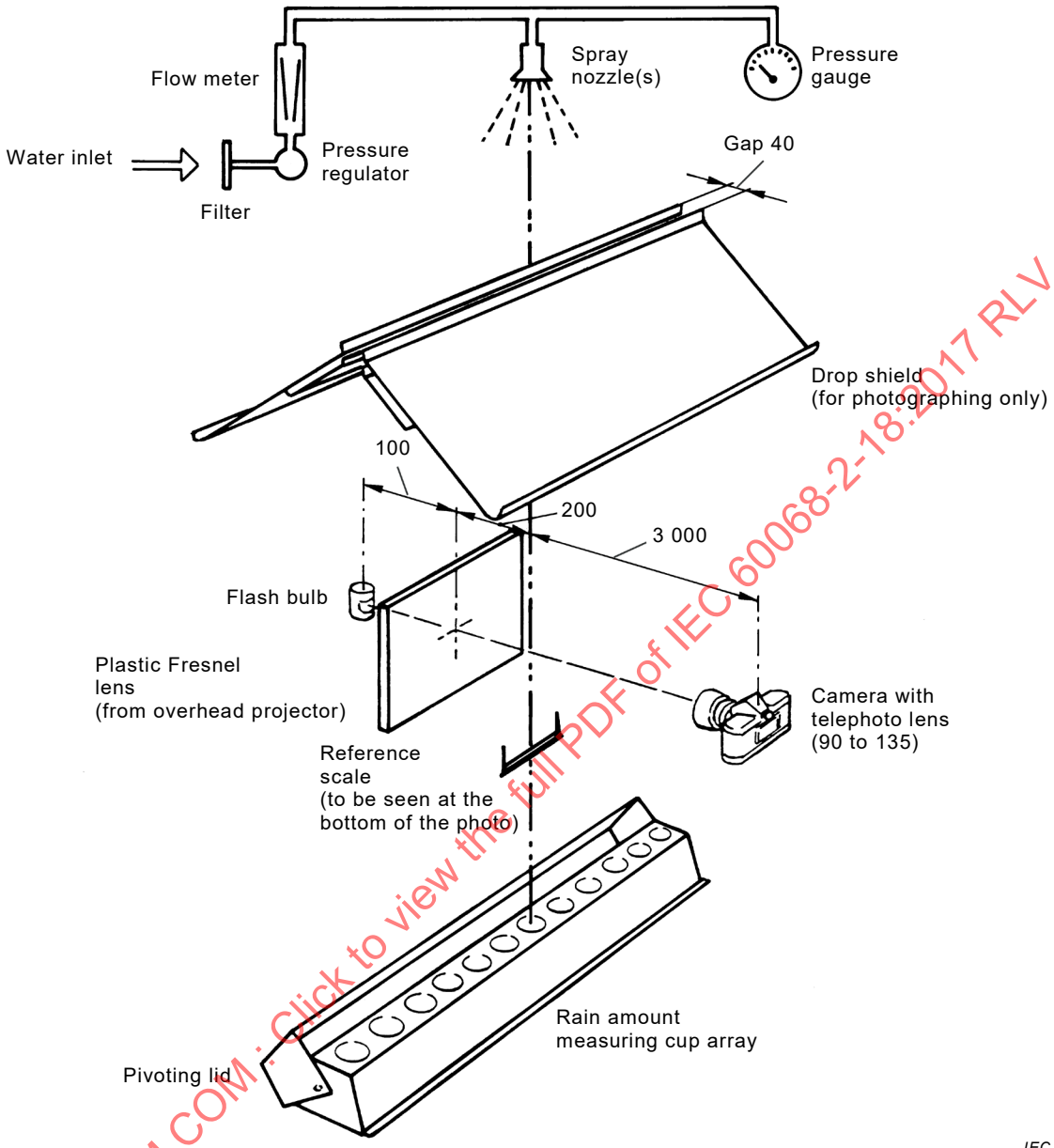
Method Ra 2: drip box, is applicable for products which normally are protected from natural rain, but may be exposed to drops falling as a result of condensation or leakage from upper surfaces.

Before deciding on the test method to be used, an assessment of which test method and test conditions are appropriate shall be made. The selected test methods and severities represent the most severe exposure anticipated for the test item when in ordinary use.

C.2 Example of test apparatus

C.2.1 Method Ra 1: artificial rain

One or more spraying nozzles of commercially available "solid cone" type are arranged to give the specified intensity (see Figure C.1). A "solid cone" nozzle is one that, within its entire cone area, has a fairly even intensity distribution. This distinguishes it from the plain nozzle which gives a hollow cone type spray pattern.



NOTE 1 The distance between the spray nozzle and the cup area is approximately 2 500 mm.

NOTE 2 The set-up shown is a confirmation device.

Figure C.1 – Test Ra 1, test apparatus and measurement setup for drop sizes and intensity for artificial rain method

C.2.2 Method Ra 2: drip box

The apparatus required consists of a water container of adequate plan dimensions having a number of nozzles, spaced at intervals of 20 mm or 25 mm on a square grid in its base, which permit the water to drip freely and per orifice, at the specified intensities. The size of the container will depend upon the mean area of the specimen to be tested: it may be restricted to such dimensions as to cover selected critical areas of large specimens if permitted by the relevant specification. Figure C.2 gives details of an apparatus currently in use for this test.

This arrangement results in drops of 3 mm to 5 mm in diameter.

C.3 Verification of test apparatus

C.3.1 Intensity

To measure the intensity of the artificial rain as well as that of the drip box, a number of cups placed in a row can be used. The cup array should be equipped with a pivoting lid (see Figure C.1).

The intensity at the location of any one cup is:

$$R = \frac{V \times 6}{A \times t}$$

where

R is the intensity in mm/h;

V is the sampled volume in cm^3;

A is the area of the cup in dm^2;

t is the measuring time in min.

C.3.2 Drop size

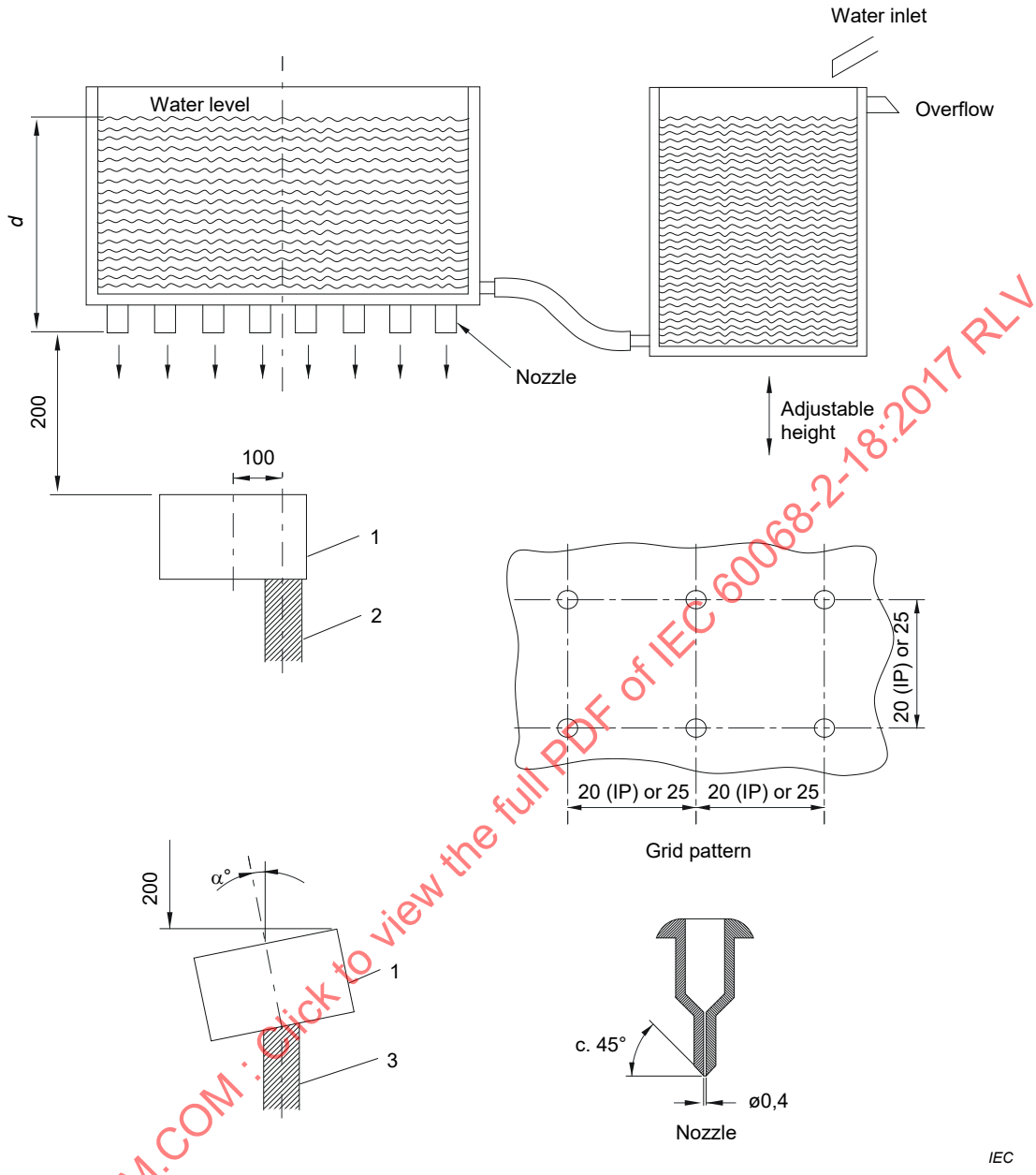
From a picture taken on a thin section through the drop field it is possible to determine the drop size. For the drops to appear clearly and distinctly, a short-duration electronic flash and a Fresnel lens may be used (see Figure C.1). A flash duration of not more than 10 μs, generated, for example, by single-flash triggering of a good stroboscope of the type used in vibration testing is suitable. The drop field size as a function of intensity (or feeding pressure) is fairly stable over time for a specific nozzle set-up.

After initial confirmation the test apparatus will need to be re-checked only when, for example, clogging of the nozzles by impurities may have occurred and been corrected.

C.3.3 Resistivity and pH value

See A.3.1.

Dimensions in millimetres



1 Test specimen

2 Turntable

3 Support

NOTE 1 The intensity is controlled by adjusting the water level (*d*).

NOTE 2 This apparatus is commonly in use and is commercially available, but a different test apparatus, including different nozzles, can be used if it can be demonstrated that the results obtained are identical.

Figure C.2 – Test Ra 2, recommended test apparatus for the drip box method

Annex D
(informative)

Guidance for test Rb

D.1 General

Test Rb: impacting water, comprises three test methods

Method Rb 1: oscillating tube and spray nozzle are applicable for products which may be exposed to water from sprinkler systems or spray from wheels.

Method Rb 2: water jet is applicable for products which may be exposed to flushing, sluicing or breaking seas.

Method Rb3. fan jet nozzle is applicable for products which may be exposed to high pressure and high temperature water spraying.

The selected test method and the severities should represent the most severe exposure for the test item when in ordinary use. Provisions should be made regarding mounting and installation of the specimen, for example by the use of an artificial roof, ceiling or wall and also the procedure with regard to drain holes and ventilation openings.

If method Rb 1 is selected, the oscillating tube should be chosen as the test method, provided the dimensions and shape of the test specimen are such that the radius does not exceed 1,6 m. Where this condition cannot be fulfilled, a spray nozzle should be used.

D.2 Example of test apparatus

D.2.1 Method Rb 1: oscillating tube and spray nozzle

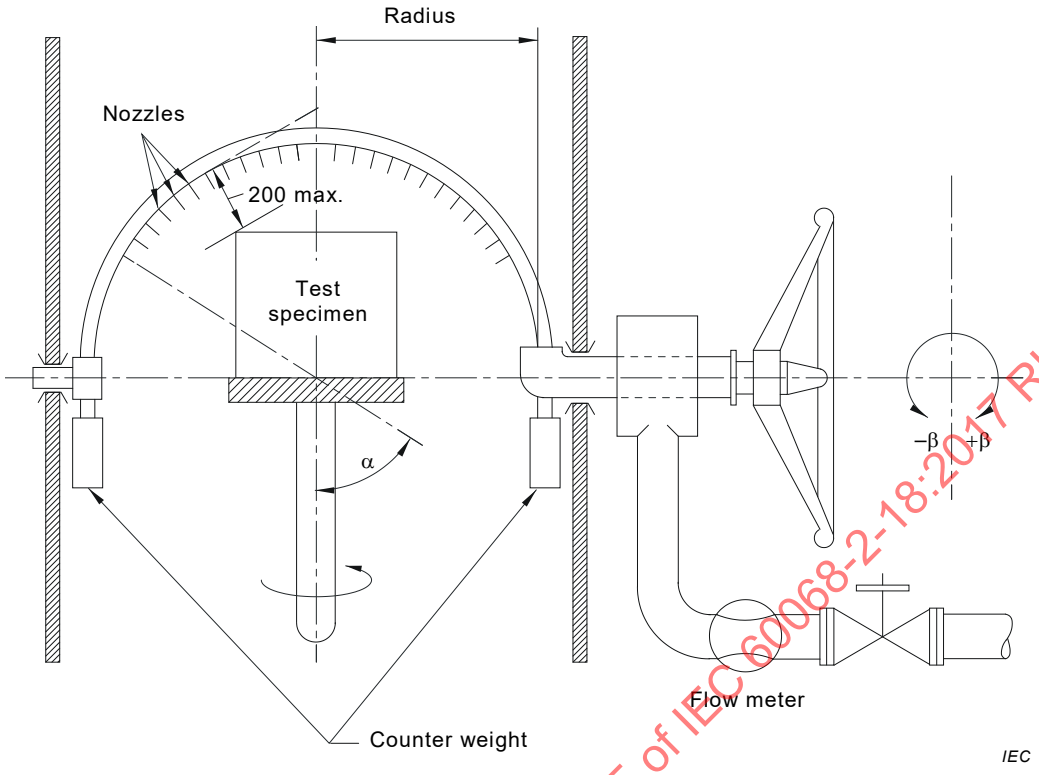
D.2.1.1 Method Rb 1.1: oscillating tube

Depending on the chosen severity and of the type of oscillating tube:

- the oscillating tube is provided with straight flow nozzles of 0,4 mm or 0,8 mm in diameter at 50-mm centre-to-centre distances.

  The nozzles are positioned over an angle (α) of 60° or 90° on either side of the centre point of the oscillating tube. The mean flow rate through each nozzle is 0,07 l/min or 0,6 l/min;
- the oscillating tube should be oscillated – at a rate of 30°/s – through an angle (β) of 60° or 180° (approximately) on either side of the vertical centre plane;
- the support is placed at the centre of the semicircle of the tube and should be movable up and down so that all relevant parts of the specimen are wetted during the test;
- the support should be lockable in one defined position or be adjustable in two positions located through a horizontal angle of 90°;
- the support should not be perforated (for example, for testing of IPX3 of IEC 60529) or should be suitably perforated (for example, for testing of IPX4 of IEC 60529);
- the test specimen is mounted on the support at approximately the centre point of the semicircle of the tube.

Figure D.1 shows the principle design of a test apparatus for Rb 1.1.



NOTE 1 The nozzles have a centre-to-centre distance of 50 mm.

NOTE 2 This method does not work well when the spray tube radius exceeds 1 600 mm.

NOTE 3 α is the angle of arc on either side of the vertical of the section of the oscillating tube fitted with nozzles. β is the angle of rotation of the oscillating tube on either side of the vertical.

NOTE 4 This apparatus is commonly in use and is commercially available, but a different test apparatus, including the nozzles, can be used if it can be demonstrated that the results obtained are identical.

Figure D.1 – Test Rb 1.1, recommended test apparatus for the oscillating tube method

NOTE When testing IPX3 or IPX4 of IEC 60529, the test specimen is placed in one defined position while the tube is oscillated through the specified angles; only for IPX3 the specimen is turned once after 5 min test duration into a second fixed position through a horizontal angle of 90° and the test is then continued for the remaining test duration of 5 min.

For a specified set of measurement conditions, Figure D.2 gives an indication of the distribution of the precipitation intensity that can be expected within a specific test volume (radius of the oscillating tube: 1 000 mm).

D.2.1.2 Method Rb 1.2: spray nozzle

The spray nozzle should be used when larger specimens are to be tested. The moving shield can be in place or removed during the test. When the specimen has to be sprayed from all practicable directions, the shield has to be removed from the spray nozzle (see also Figure D.3).

D.2.2 Method Rb 2: water jet

This test is performed by spraying the specimen from the specified direction with a stream of water from a standard test nozzle. The test specimen should be mounted on a perforated fixture and should preferably be capable of rotation.

For the test, two sizes of nozzles are available having an internal diameter of 6,3 mm and of 12,5 mm. For the small nozzle, the delivery rate should be 12,5 (1 ± 5 %) l/min, which requires a pressure of approximately 30 kPa (0,3 bar) or 75 (1 ± 5 %) l/min requiring approximately 1 000 kPa (10 bar). The larger nozzle should have a delivery rate of 100 (1 ± 5 %) l/min requiring a pressure of approximately 100 kPa (1 bar) (see also Figure D.4).

D.2.3 Method Rb 3: fan jet nozzle

The test is made by spraying the specimen with a stream of high-pressure and high-temperature water from the test nozzle shown in Figures D.5, D.6 and D.7.

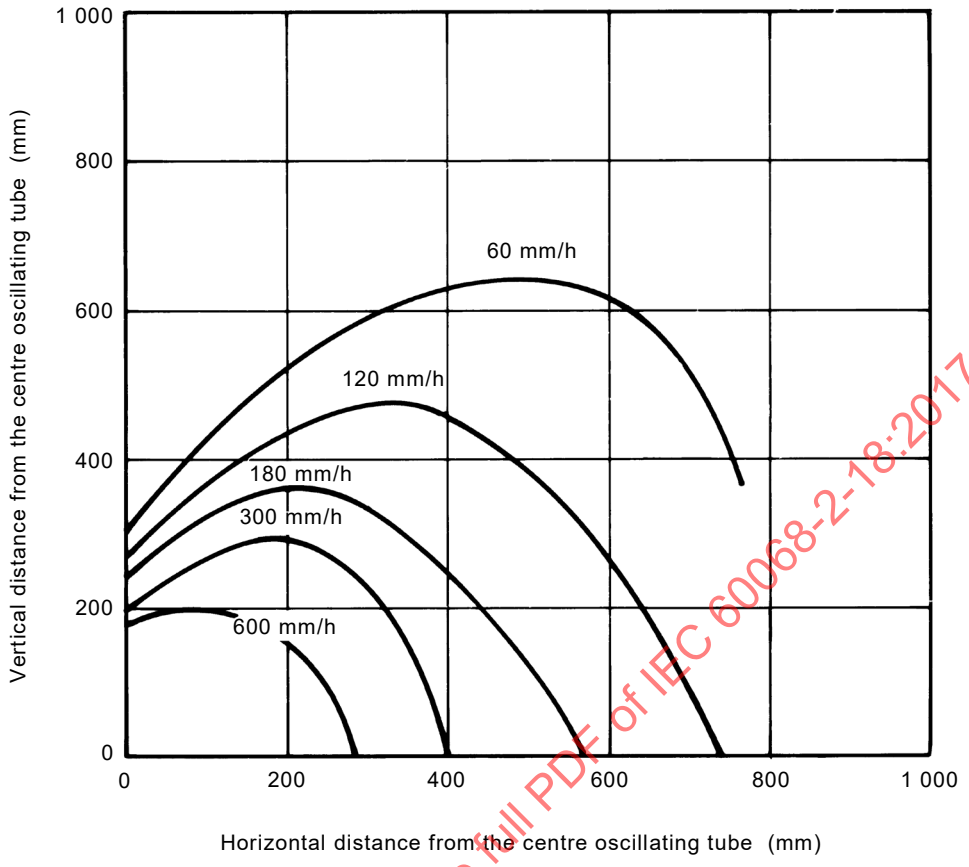
The set-up for measuring the impact force of the water jet is given in Figure D.8 and the distribution force shall be verified at upper and lower limits of distance tolerance range (see Figure D.9).

During the test a) or b) of the enclosure, the water temperature shall be (80 ± 5) °C.

a) For small enclosures (largest dimension less than 250 mm), the enclosure shall be mounted on the turntable shown in Figure D.10.

b) For large enclosures (largest dimension greater than or equal to 250 mm), the enclosure shall be mounted as per its intended use. The entire exposed surface area of the enclosure shall be subjected to the spray at some point during the test procedure. The enclosure shall be sprayed from all practical directions covering the entire surface area and the spray shall be, as far as possible, perpendicular to the sprayed surface.

Dimensions in millimetres

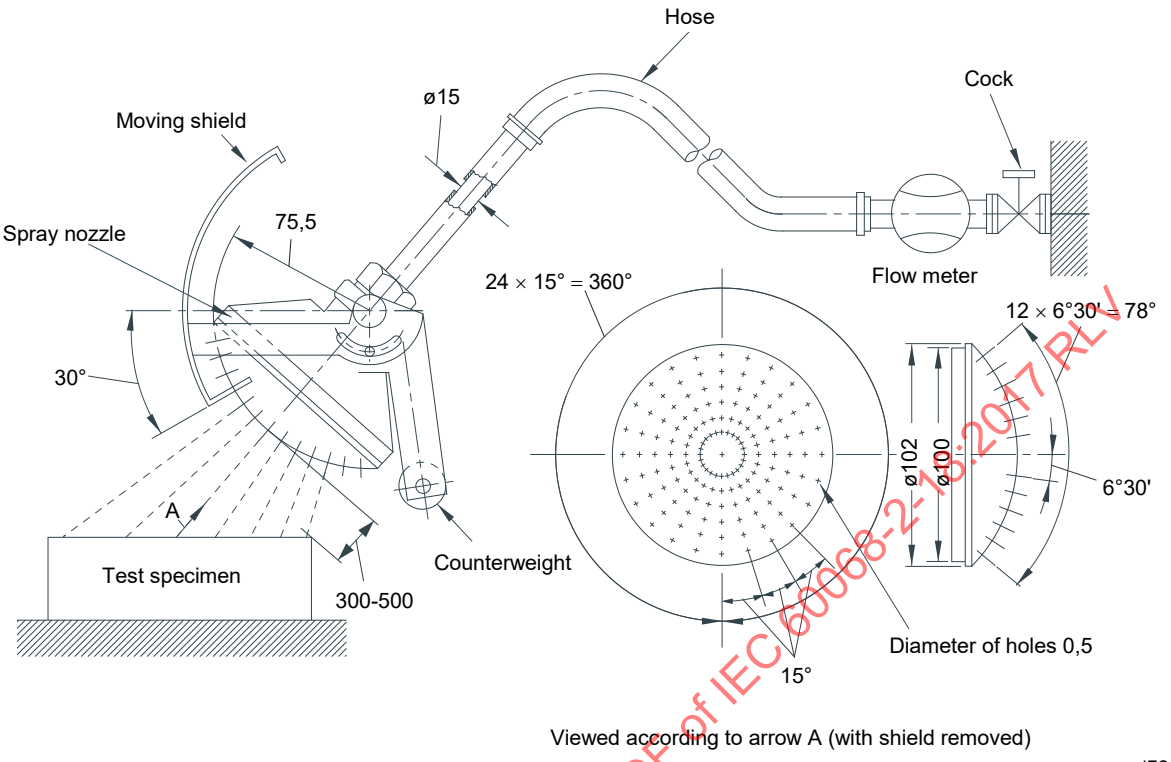


Measurement conditions

Nozzle diameter:	0,4 mm
Radius of oscillating tube:	1 000 mm
Water pressure at inlet:	80 kPa which corresponds to a water flow of approximately 0,1 l/min per nozzle
Nozzle angle:	α = 60°
Tube oscillating angle:	β = 60°
Measurement time:	20 min

Figure D.2 – Distribution of mean value of precipitation intensity in the oscillating tube area

Linear dimensions in millimetres



Key

121 holes of ø0,5

1 hole at the centre

2 inner circles of 12 holes at 30° pitch

4 outer circles of 24 holes at 15° pitch

Moving shield – aluminium

Spray nozzle – brass

NOTE This apparatus is commonly in use and is commercially available, but a different test apparatus can be used if it can be demonstrated that the results obtained are identical.

Figure D.3 – Test Rb 1.2, recommended test apparatus for the spray nozzle method

Linear dimensions in millimetres

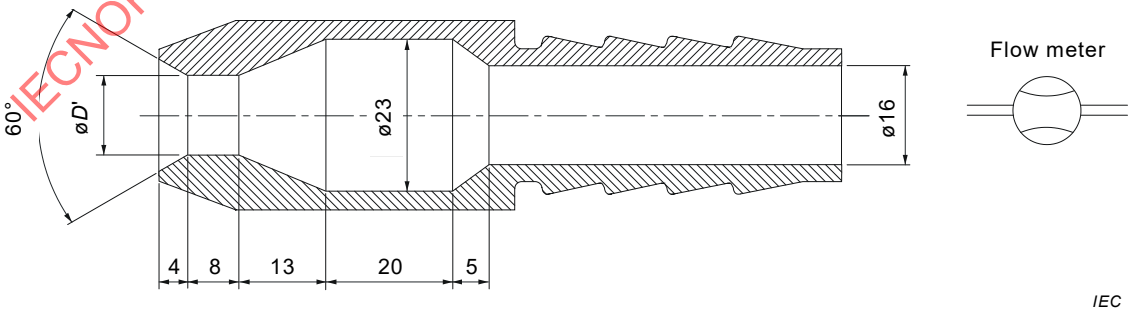
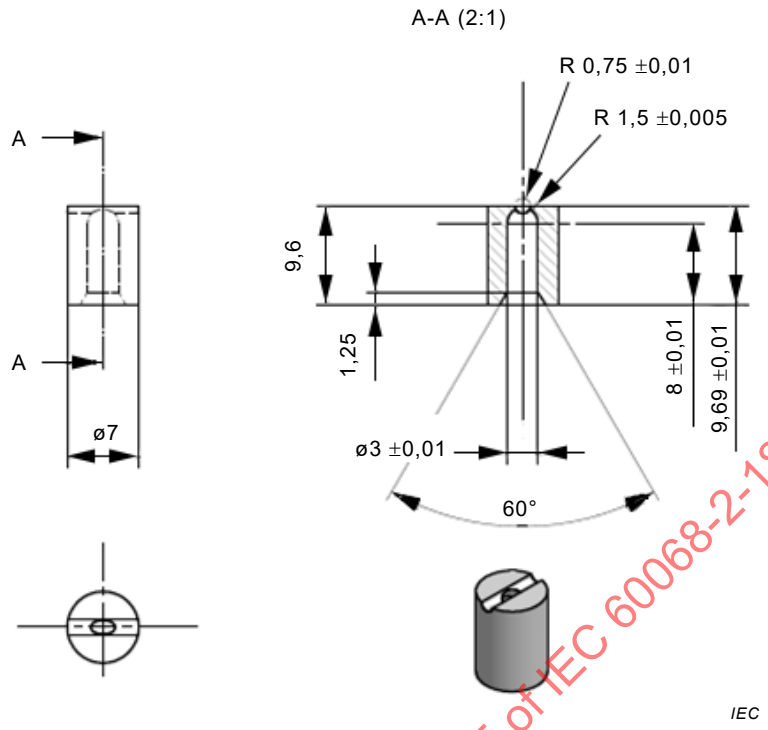


Figure D.4 – Standard test nozzle for the water jet method (hose nozzle)

Dimensions in millimetres



NOTE The dimension 9,69 ± 0,01 refers to the centre of the radius R 0,75 ± 0,01.

Figure D.5 – Standard test nozzle for the fan jet method

Dimensions in millimetres

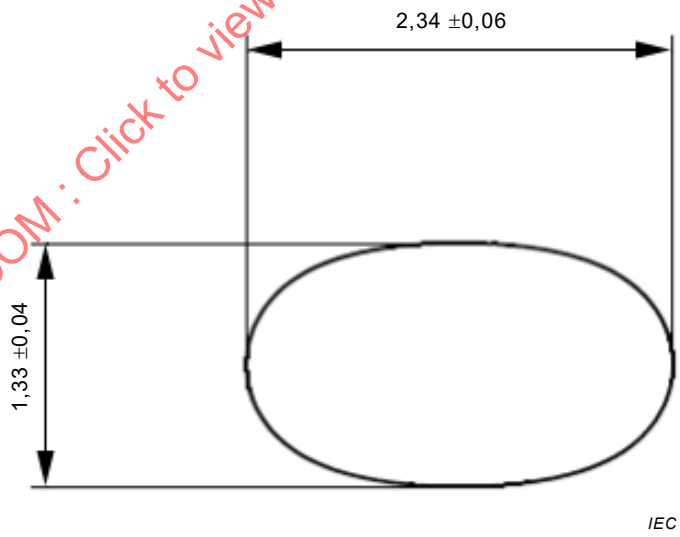
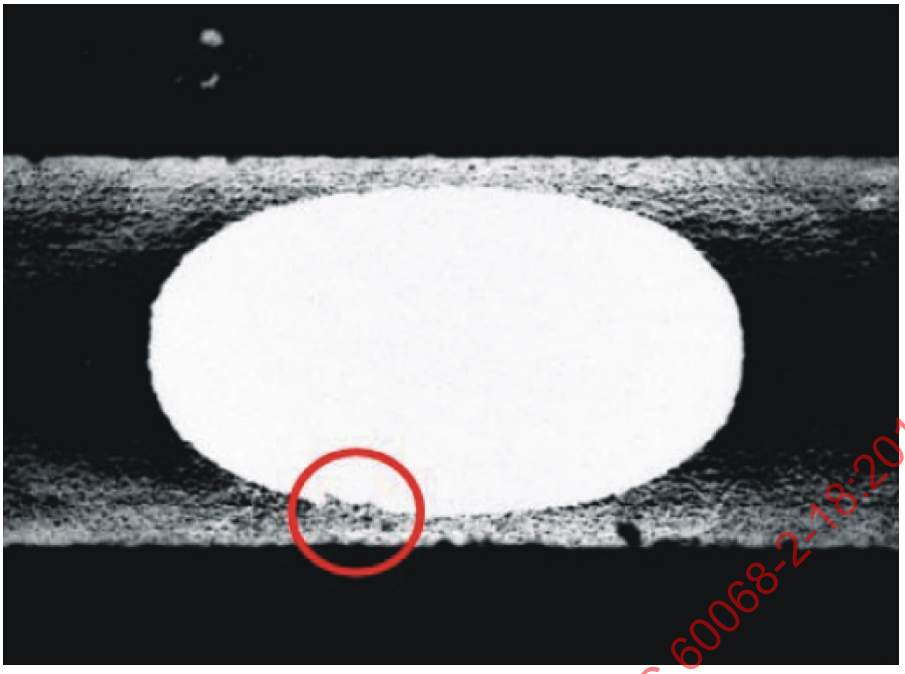
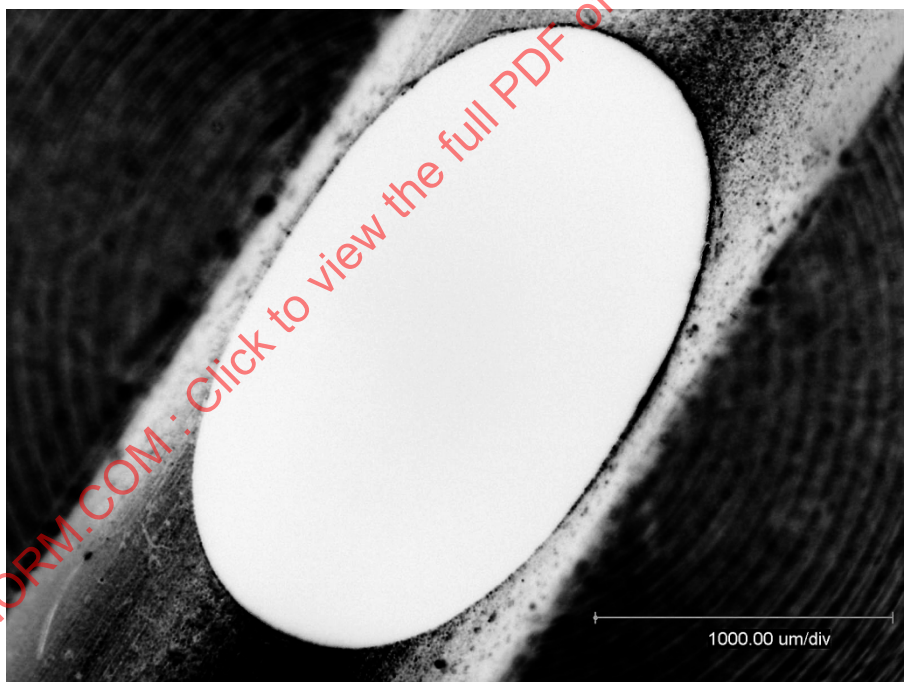


Figure D.6 – Fan jet nozzle resulting dimensions of spraying hole for checking purpose



Bad surface finish

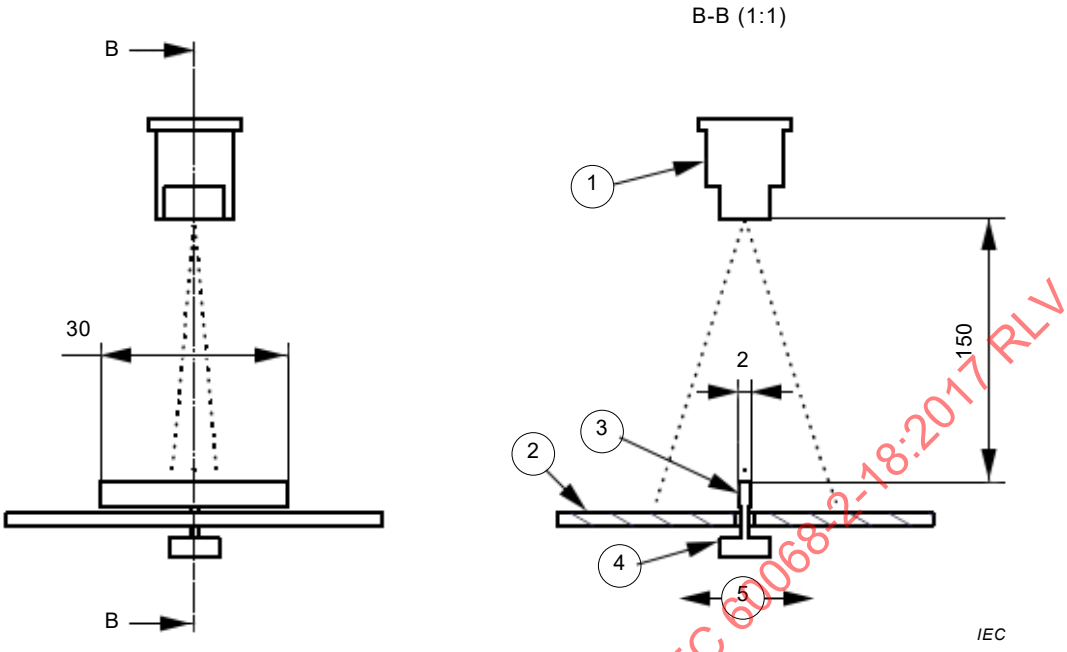


Good surface finish

IEC

Figure D.7 – Example of different quality achievements of the surface finish of the fan jet nozzle

Dimensions in millimetres



Key

1 fan jet nozzle: adjustment of the flow – rate between (15 ± 1) l/min to reach a distribution impact force of 0,9 N to 1,2 N. Water temperature during verification (20 ± 5) °C.

2 cover plate

3 impact plate 2 mm × 30 mm

4 force sensor

5 distribution forces directions (see also Figure D.9)

Figure D.8 – Set-up for measuring the impact force of the water jet for determining the protection against high-pressure and high-temperature water jets

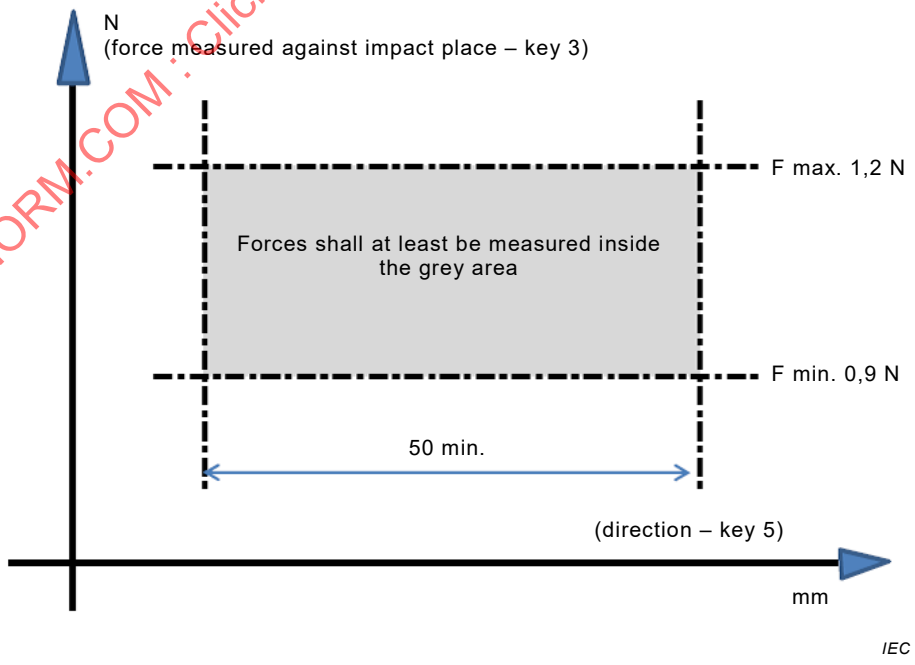
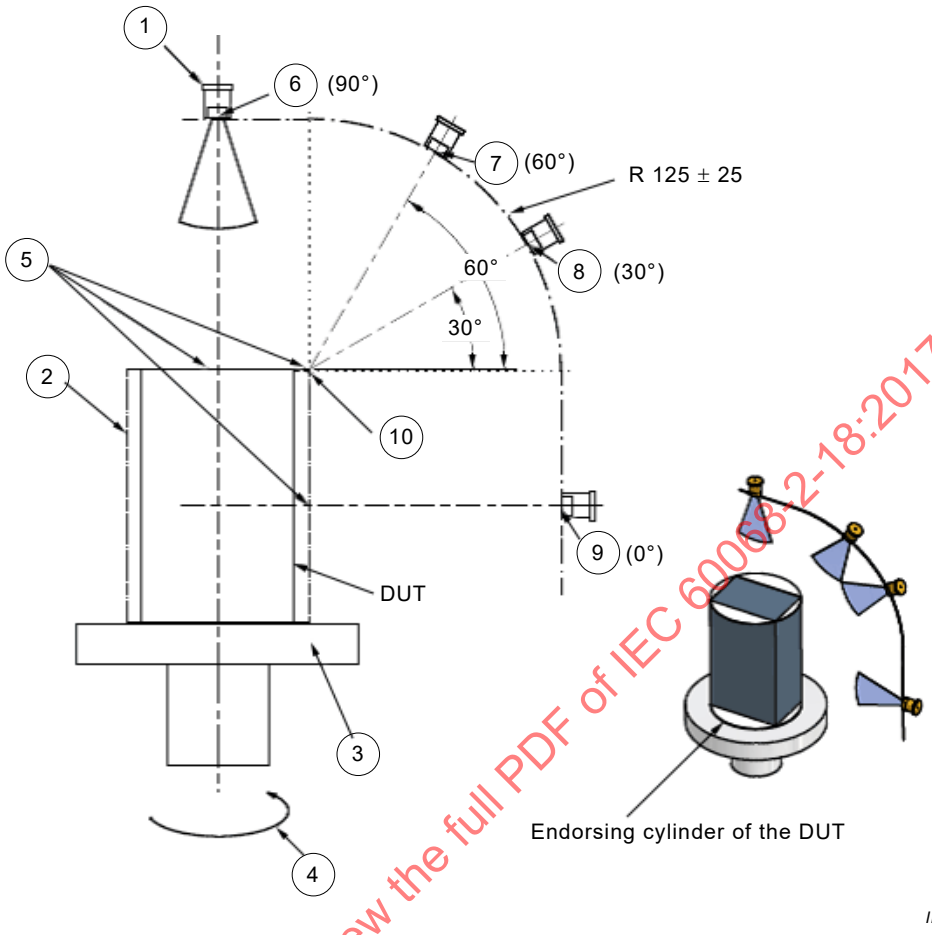


Figure D.9 – Impact force distribution

Dimensions in millimetres



Key

1	fan jet nozzle	6	position 1 of the nozzle (90°)
2	endorsing cylinder for DUT	7	position 2 of the nozzle (60°)
3	holder (rotating table)	8	position 3 of the nozzle (30°)
4	swivel axis (axis of rotation)	9	position 4 of the nozzle (0°)
5	reference point for 0°, for 30° and 60°, then for 90° versus the endorsing cylinder for DUT	10	centre point of circle R 125 mm to locate nozzles

Figure D.10 – Test setup for determining the protection against high-pressure and high-temperature water jet for small enclosures

Annex E
(informative)

Guidance for test Rc

E.1 General

Test Rc: Immersion comprises two test methods

Method Rc 1: Water tank and method Rc 2: Pressurized water chamber are both applicable for products which, during transportation or in service, may be subjected to immersion.

E.2 Example of test apparatus

E.2.1 Method Rc 1: water tank

The required test apparatus should include a water container which can achieve a covering depth of 1 m (or other required depths) of water over the uppermost point of the specimen and maintain the test specimen at that depth.

A water soluble dye such as fluorescein may be added to the water to aid locating and analysing water leaks. Manufacturer's instructions should be followed.

E.2.2 Method Rc 2: pressurized water chamber

The required test apparatus is a positive pressure chamber containing a water tank capable of holding the specimen and covering it with water.

A water soluble dye such as fluorescein may be added to the water to aid locating and analysing water leaks. The manufacturer's instructions should be followed.

E.3 Verification of test apparatus

This is done by measuring the depth of immersion for test Rc 1, or the water pressure for test Rc 2. Measurements of resistivity and pH values are made if required by the relevant specification.

Bibliography

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

_____

ESSAIS D'ENVIRONNEMENT –

Partie 2-18: Essais – Essai R et guide: Eau

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Cette troisième édition annule et remplace la deuxième édition parue en 2000. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) ajout de la nouvelle méthode d'essai Rb 3.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
104/719/FDIS	104/722/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60068, publiées sous le titre général *Essais d'environnement*, peut être consultée sur le site web de l'IEC.

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- amendée.

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INTRODUCTION

Un certain nombre d'essais d'eau sont décrits dans d'autres publications de l'IEC. Certains sont bien établis, comme les essais de classification du deuxième chiffre caractéristique du code IP de l'IEC 60529.

Le présent document intègre la plupart des essais les plus largement utilisés. Il présente également d'autres méthodes et augmente le nombre des sévérités.

ESSAIS D'ENVIRONNEMENT –

Partie 2-18: Essais – Essai R et guide: Eau

1 Domaine d'application

La présente partie de l'IEC 60068 spécifie les méthodes d'essai applicables aux produits qui, pendant leur transport, leur stockage, ou alors qu'ils sont en service, peuvent être soumis à des chutes de gouttes d'eau, à des projections d'eau, à une immersion ou à des projections d'eau à haute pression. Le but premier des essais d'eau est de vérifier l'aptitude des enveloppes, des couvercles et des joints d'étanchéité à maintenir les composants et les matériels en bon état de marche après et, si besoin, pendant un arrosage par des gouttes d'eau ou une immersion dans l'eau normalisée.

Ces essais ne sont pas des essais de corrosion et ne peuvent pas être considérés ou utilisés comme tels.

Les essais d'eau déjà établis dans d'autres normes ne sont pas destinés à simuler les chutes de pluie naturelles et leurs intensités correspondantes sont trop élevées pour être utilisées dans ce but. En conséquence, en plus des sévérités de forte intensité, l'essai R comprend un essai de pluie artificielle basé sur des conditions naturelles, mais sans tenir compte des grands vents qui sont généralement associés à la pluie naturelle.

Des préconisations sont données sur l'applicabilité des essais et sur les sévérités à choisir.

2 Références normatives

Le présent document ne contient aucune référence normative.

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC maintiennent des bases de données terminologiques pour une utilisation dans la normalisation aux adresses suivantes:

- IEC Electropedia: disponible à http://www.electropedia.org/
- plateforme de navigation en ligne ISO: disponible à http://www.iso.org/obp

3.1
pluie
précipitation sous forme de gouttes d'eau

Note 1 à l'article: La quantité d'eau qui tombe ainsi que l'action de chute effective de gouttes d'eau sont souvent appelées chutes de pluie.

3.2
bruine
précipitations sous forme de gouttes d'eau très petites, nombreuses et uniformément dispersées qui peuvent flotter lorsqu'elles suivent les courants d'air

3.3
gouttes de pluie
goutte d'eau d'un diamètre supérieur à 0,5 mm traversant l'atmosphère

3.4
goutte de bruine
goutte d'eau d'un diamètre compris entre 0,2 mm et 0,5 mm traversant l'atmosphère

3.5
R
intensité de chute de pluie ou de bruine
quantité de pluie ou de bruine qui tombe par unité de temps

Note 1 à l'article: L'intensité de chute de pluie (R) est donnée en millimètres par heure (mm/h) où 1 l/(m^2 · h) est égal à 1 mm/h.

3.6
D_{50}
diamètre du volume moyen

diamètre d'une goutte dont la taille est telle que 50 % du volume d'eau touchant le sol est composé de gouttes plus petites (ou plus grandes)

Note 1 à l'article: Le diamètre volumétrique moyen peut être calculé à l'aide de la formule:

$D_{50} = 1{,}21\ R^{0{,}19}$ (mm)

où R est l'intensité de la chute de pluie (voir 3.5).

4 Résumé des essais d'eau

4.1 Généralités

Ce résumé indique la structure générale des différents essais spécifiés dans le présent document.

La structure des différents essais est donnée à la Figure 1.

4.2 Description des essais R: eau

Les essais d'eau se répartissent en trois groupes.

- Ra: «chutes de gouttes d'eau» qui, en principe, est un essai de pluie artificielle et un essai simulant des chutes de gouttes d'eau ayant comme origine la condensation ou les fuites.
- Rb: «projections d'eau» au cours desquelles des jets d'eau frappent le spécimen en essai avec une certaine force et les gouttes peuvent prendre un angle quelconque en direction du spécimen en essai.
- Rc: «immersion» pendant laquelle le spécimen en essai est immergé dans l'eau à des profondeurs spécifiées ou à des pressions équivalentes.

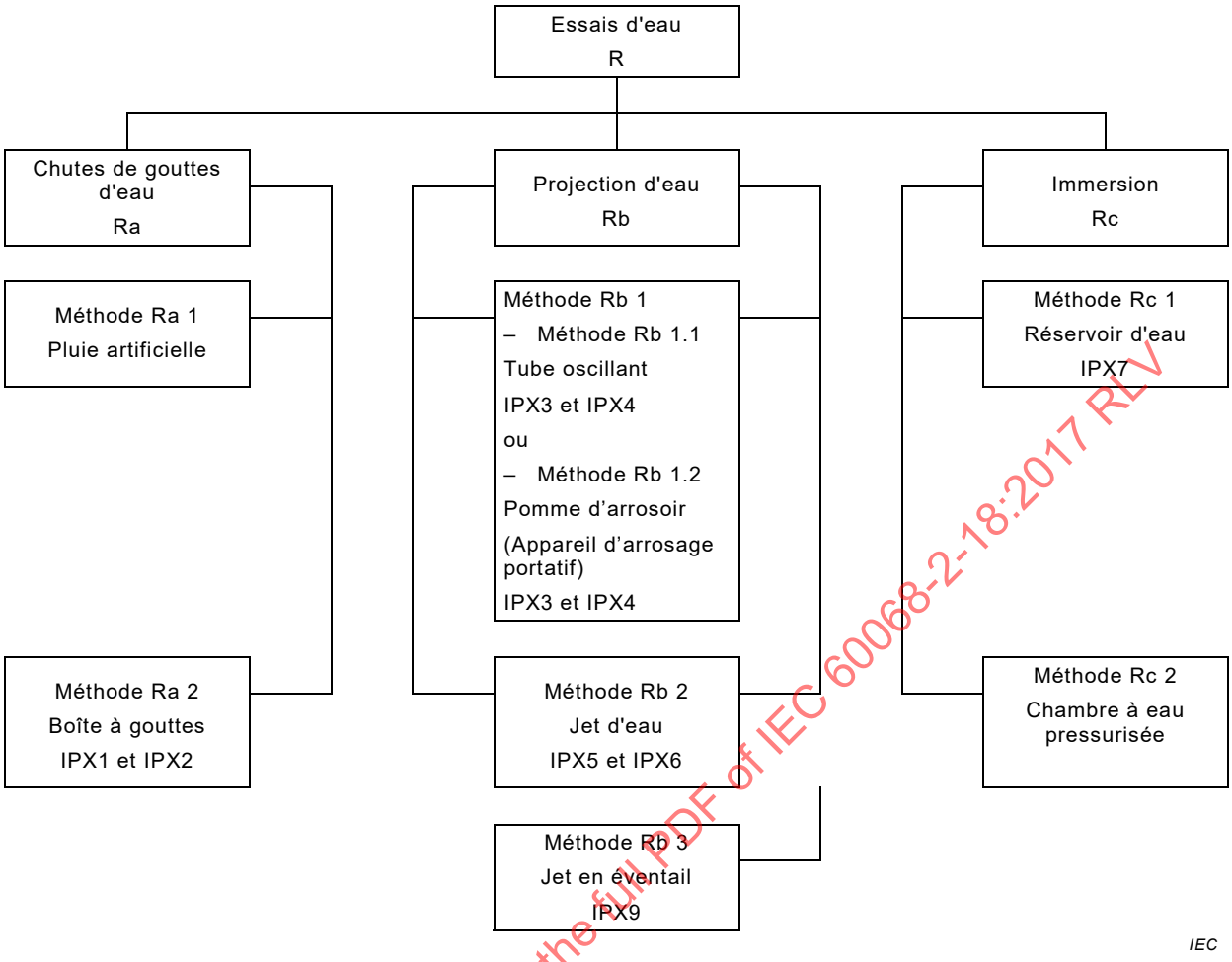

Figure 1 – Synthèse des méthodes d'essai et équivalence avec le code IP de l'IEC 60529

5 Essai Ra: chute de gouttes d'eau

5.1 Objet

Cet essai s'applique aux produits qui, pendant leur transport, le stockage ou lorsqu'ils sont en service, peuvent être exposés à des chutes de gouttes d'eau verticales, l'origine de ces chutes étant, par exemple, la pluie naturelle, les infiltrations ou la condensation. La spécification particulière doit clairement indiquer si un produit, désigné ci-après spécimen, doit fonctionner pendant les essais ou simplement subir sans dommage les conditions de chutes de gouttes d'eau. Dans les deux cas, la spécification particulière doit toujours spécifier les tolérances de fonctionnement acceptables.

5.2 Méthode Ra 1: pluie artificielle

5.2.1 Description générale de l'essai

Le spécimen en essai est fixé sur un support ou sur un socle approprié. Il est ensuite soumis à des chutes de gouttes d'eau qui simulent une pluie naturelle.

Les exigences fondamentales du dispositif d'essai sont comme suit:

- Une ou plusieurs buses produisant des gouttes (voir C.2.1 et la Figure C.1).
- Support de fixation pour le spécimen

Le support de fixation doit, dans toute la mesure du possible, simuler le montage du spécimen quand il est en service. Par exemple, pour un appareil mural, le support doit simuler un mur.

- Support du spécimen

  Le support doit avoir une surface de base plus petite que celle du spécimen. Le support doit être soit une table pivotante ayant une vitesse de rotation de 1 r/min et une excentricité (distance séparant l'axe de la table tournante de celui du spécimen) de 100 mm environ, soit une table fixe. Le support doit pouvoir maintenir le spécimen dans une position quelconque et, si nécessaire, être inclinable en formant un angle maximal de 90° par rapport au plan vertical.

- Alimentation en eau avec commandes

  L'eau utilisée pour l'essai doit être de l'eau douce du robinet, de bonne qualité. Pour éviter l'obturation des buses, l'eau doit être filtrée et peut être déminéralisée. Les caractéristiques de l'eau sont données dans l'Annexe A. Au cours de l'essai, la température de l'eau ne doit pas varier de plus de 5 K par rapport à la température du spécimen en essai. Si la température de l'eau est inférieure de plus de 5 K à la température du spécimen, un rééquilibrage en pression doit être réalisé pour le spécimen.

5.2.2 Sévérités

Les sévérités, définies par l'intensité (et la répartition de la taille associée) des gouttes, par leur durée et l'angle d'inclinaison du spécimen, doivent être précisées dans la spécification particulière. Les valeurs doivent être choisies parmi celles indiquées ci-dessous, une durée plus longue peut être spécifiée dans le cahier des charges correspondant. La pluie dirigée par le vent n'est pas simulée par cet essai, dans la mesure où la vitesse du vent n'est pas un paramètre d'essai.

- Intensité, mm/h et (la répartition de la taille des gouttes associée, mm):

  10 ± 5 (D_{50} = 1,9 ± 0,2); 100 ± 20 (D_{50} = 2,9 ± 0,3); 400 ± 50 (D_{50} = 3,8 ± 0,4).

- Durée, min:

  10, 30, 60, 120.

- Angle d'inclinaison α, degrés:

  0, 15, 30, 60, 90.

5.2.3 Préconditionnement

Le préconditionnement du spécimen et des joints d'étanchéité doit être réalisé s'il est précisé dans la spécification particulière.

5.2.4 Mesures initiales

Le spécimen doit être soumis aux vérifications visuelles, dimensionnelles et fonctionnelles précisées dans la spécification particulière. Toutes les particularités du spécimen susceptibles d'affecter le résultat d'essai, par exemple le traitement de surface, les enveloppes, les couvercles ou les joints d'étanchéité, doivent être vérifiées pour s'assurer que les instructions de la spécification particulière ont bien été respectées.

5.2.5 Essais

Le spécimen doit être monté sur le support, soit

- dans sa position normale de fonctionnement, comme précisé dans la spécification particulière, soit
- incliné à partir de sa position normale de fonctionnement et de telle sorte qu'il puisse tourner dans un plan perpendiculaire à l'axe incliné. La rotation peut être réalisée à l'aide d'une table support tournante ou en replaçant le spécimen à intervalles réguliers pendant

l'essai. En variante, le spécimen peut être mis en oscillation en formant un angle de 270° pour éviter d'utiliser des contacts à bagues.

La spécification particulière doit préciser l'angle ou les angles d'inclinaison, la ou les faces exposée(s) à la chute de gouttes d'eau, ainsi que la durée d'exposition pour chaque face, ou si le spécimen doit tourner ou osciller en permanence en formant un angle de 270°. Voir également la Figure 2.

Le spécimen doit être soumis à la pluie artificielle avec les sévérités choisies en 5.2.2 et précisées dans la spécification particulière.

La spécification particulière doit indiquer si le spécimen doit être mis en fonctionnement pendant les essais et si des mesures intermédiaires doivent être réalisées.

Des mesures de sécurité appropriées doivent être prises lors des essais sous tension.

5.2.6 Reprise

Sauf exigences contraires dans la spécification particulière, le spécimen doit être soigneusement séché extérieurement en l'essuyant ou en lui appliquant une circulation d'air forcé de faible intensité à la température ambiante.

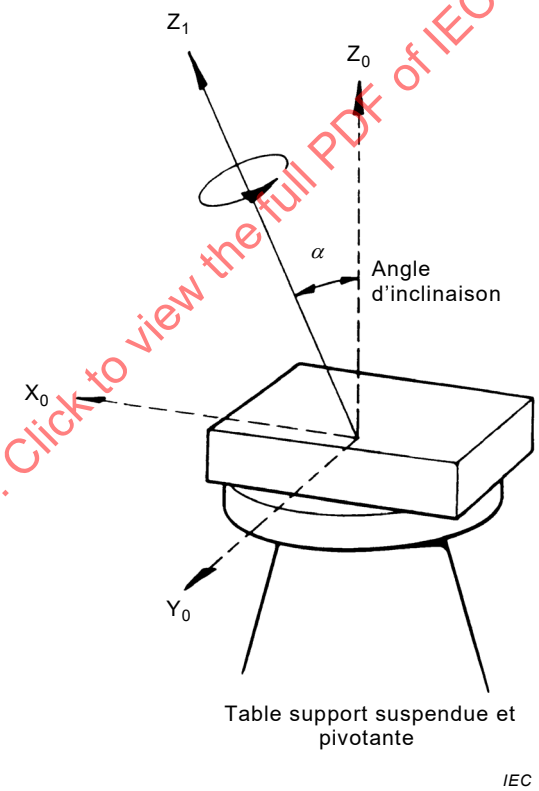

Figure 2 – Essai Ra, définitions des angles et des axes

5.2.7 Mesures finales

Le spécimen doit être examiné pour vérifier s'il y a eu pénétration d'eau et doit être soumis aux vérifications visuelles, dimensionnelles et fonctionnelles précisées dans la spécification particulière.

Il convient de quantifier, lorsque cela est possible, toute pénétration d'eau et de la noter.

5.2.8 Informations à fournir dans la spécification particulière

Si cet essai est inclus dans la spécification particulière, les informations suivantes doivent être fournies dans la mesure où elles s'appliquent. La spécification particulière doit fournir les informations exigées dans les paragraphes indiqués ci-dessous, en prêtant une attention particulière aux points marqués d'un astérisque (*), symbole indiquant qu'une information est toujours exigée.

	Paragraphe
a) Sévérités*	5.2.2
b) Préconditionnement	5.2.3
c) Mesures initiales*	5.2.4
d) Montage du spécimen*	5.2.5
e) La ou les positions du spécimen au cours des essais*	5.2.5
f) État du spécimen pendant les essais*	5.2.5
g) Mesures intermédiaires	5.2.5
h) Reprise	5.2.6
i) Mesures finales*	5.2.7

5.3 Méthode Ra 2: boîte à gouttes

5.3.1 Description générale de l'essai

Le spécimen en essai est fixé sur un support approprié placé sous la boîte à gouttes. Le spécimen en essai est soumis à des gouttes d'eau qui simulent la chute de gouttes d'eau de condensation ou des gouttes provenant d'une fuite d'eau.

Les exigences fondamentales du dispositif d'essai sont les suivantes:

- Boîte à gouttes

  La boîte à gouttes doit normalement avoir une surface de base plus large que la surface projetée du spécimen. Si la base de la boîte à gouttes est plus petite que celle du spécimen en essai, cette dernière peut être divisée en plusieurs sections, la surface de chaque section étant suffisamment large pour être couverte par la chute des gouttes d'eau. L'essai est poursuivi jusqu'à ce que la surface totale du spécimen ait été arrosée pendant la durée spécifiée. La boîte à gouttes doit pouvoir produire uniformément des gouttes d'eau avec une vitesse de précipitation correspondant à l'intensité spécifiée.

  L'écartement des buses situées sur la grille doit être de 20 mm (pour les essais du code IP) ou de 25 mm. La distance séparant le fond de la boîte à gouttes et la partie supérieure du spécimen doit être réglable à 0,2 m ou à 2 m. Un schéma approprié de boîte à gouttes est décrit en C.2.2 et à la Figure C.2.

- Support de fixation du spécimen

  Le support de fixation doit simuler autant que possible le montage du spécimen quand celui-ci est en service. Par exemple, pour un matériel mural, le support de fixation doit simuler un mur.

- Support du spécimen en essai

  Le support doit avoir une surface de base plus petite que celle du spécimen. Le support doit être soit une table tournante ayant une vitesse de rotation de 1 r/min et une excentricité (distance séparant l'axe de la table tournante de celui du spécimen) de 100 mm environ, soit une table fixe. Le support doit pouvoir maintenir le spécimen dans une position quelconque, et si nécessaire, être inclinable en formant un angle maximal de 45° par rapport au plan vertical.

- Alimentation en eau avec dispositifs de commande

L'eau utilisée pour l'essai doit être de l'eau douce du robinet, de bonne qualité. Pour éviter l'obturation des buses, l'eau doit être filtrée et peut être déminéralisée. Les caractéristiques de l'eau sont détaillées à l'Annexe A. Au cours de l'essai, la température de l'eau ne doit pas varier de plus de 5 K par rapport à la température du spécimen en essai. Si la température de l'eau est inférieure de plus de 5 K à la température du spécimen, un rééquilibrage en pression doit être réalisé pour le spécimen.

5.3.2 Sévérités

Les sévérités telles que la hauteur de chute des gouttes, l'angle d'inclinaison du spécimen, la durée et l'intensité des chutes d'eau, doivent être précisées dans la spécification particulière. Les valeurs doivent être choisies parmi les valeurs suivantes:

- Hauteur de chute des gouttes (h), m: 0,2; 2
- Angle d'inclinaison α, degrés: 0; 15; 30; 45
- Durée, min: 3; 10; 30; 60

NOTE La durée de 3 min s'applique uniquement si un angle d'inclinaison de 0° est spécifié.

- Intensité des chutes d'eau, mm/h: $60\ ^{+30}_{0}$; $180\ ^{+30}_{0}$

5.3.3 Préconditionnement

Le préconditionnement du spécimen et des joints d'étanchéité doit être réalisé s'il est précisé dans la spécification particulière.

5.3.4 Mesures initiales

Le spécimen doit être soumis aux vérifications visuelles, dimensionnelles et fonctionnelles précisées dans la spécification particulière. Toutes les particularités du spécimen susceptibles d'affecter le résultat des essais, par exemple le traitement de surface, les couvercles ou les joints d'étanchéité, doivent être vérifiées pour s'assurer que les instructions de la spécification particulière ont bien été respectées.

5.3.5 Essais

Le spécimen doit être monté sur le support en position normale de fonctionnement, sous la boîte à gouttes. Le support doit alors être soit mis en rotation, soit incliné selon l'angle spécifié pour chacune des quatre positions d'inclinaison. Ces positions sont de part et d'autre de l'axe vertical dans des plans orthogonaux. Si une condition spéciale de montage est exigée (par exemple sur un mur ou au plafond), elle doit être précisée dans la spécification particulière.

Dans les deux cas, l'essai doit être réalisé dans les conditions spécifiées en 5.3.1 et la sévérité doit être choisie selon 5.3.2.

Dans le cas d'un support incliné, la durée doit être également répartie entre les quatre positions.

La spécification particulière doit indiquer si le spécimen doit être mis en fonctionnement pendant les essais et si des mesures intermédiaires doivent être effectuées. Des mesures de sécurité appropriées doivent être prises lors des essais sous tension.

5.3.6 Reprise

Sauf exigences contraires dans la spécification particulière, le spécimen doit être soigneusement séché extérieurement en l'essuyant ou en lui appliquant une circulation d'air forcé de faible intensité à la température ambiante.

5.3.7 Mesures finales

Le spécimen doit être examiné pour vérifier s'il y a eu pénétration d'eau et doit être soumis aux vérifications visuelles, dimensionnelles et fonctionnelles précisées dans la spécification particulière.

Il convient de quantifier, lorsque cela est possible, toute pénétration d'eau et de la noter.

5.3.8 Informations à fournir dans la spécification particulière

Si cet essai est inclus dans la spécification particulière, les informations suivantes doivent être fournies dans la mesure où elles s'appliquent. La spécification particulière doit donner les informations exigées dans les articles indiqués ci-dessous, en prêtant une attention particulière aux points marqués d'un astérisque (*), symbole indiquant qu'une information est toujours exigée.

	Paragraphe
a) Sévérités*	5.3.2
b) Préconditionnement	5.3.3
c) Mesures initiales*	5.3.4
d) Montage du spécimen*	5.3.5
e) La ou les positions du spécimen au cours des essais*	5.3.5
f) État du spécimen pendant les essais*	5.3.5
g) Mesures intermédiaires	5.3.5
h) Reprise	5.3.6
i) Mesures finales*	5.3.7

6 Essai Rb: projections d'eau

6.1 Objet

Cet essai est applicable aux produits qui, pendant le transport, le stockage ou en service, peuvent être exposés à des projections d'eau. Ces projections d'eau peuvent provenir d'averses torrentielles, d'une pluie continue, de systèmes d'arrosage, de nettoyage sous pression, d'éclaboussures provenant de roues, de lavage à grande eau ou de paquets de mer. Il convient que la spécification particulière indique clairement si un produit soumis à des essais séparément, ci-après désigné spécimen, doit fonctionner pendant les essais, ou s'il doit simplement subir, sans dommage, les conditions des projections d'eau. Dans les deux cas, la spécification particulière doit toujours préciser les tolérances de fonctionnement acceptables.

6.2 Méthode Rb 1: tube oscillant et pomme d'arrosoir

6.2.1 Description générale de l'essai

Les essais sont destinés à simuler des pulvérisations ou des éclaboussures d'eau résultant, par exemple, de l'action de l'eau des systèmes d'arrosage. Des préconisations sur cet essai sont données dans l'Annexe D. L'essai est réalisé en utilisant soit le dispositif d'essai décrit à la Figure D.1, soit le dispositif d'essai décrit à la Figure D.3, conformément à la spécification particulière. Le spécimen en essai est monté sur un support de fixation approprié, et est soumis à des projections d'eau provenant d'un tube semi-circulaire ou d'une pomme d'arrosoir.

6.2.2 Méthode Rb 1.1: tube oscillant

6.2.2.1 Dispositif d'essai

Les exigences fondamentales du dispositif d'essai sont les suivantes:

- Tubes oscillants

  Trois types de tubes peuvent être utilisés. Le tube doit être équipé de buses de 0,4 mm de diamètre pour les types 1 et 2 ou de 0,8 mm de diamètre pour le type 3, distantes de 50 mm d'axe à axe, et réparties sur un arc de 60° de part et d'autre de l'axe vertical pour le type 1 ou sur un arc de 90° de part et d'autre de l'axe vertical pour les types 2 et 3. Le tube doit pouvoir osciller dans un angle de 60° de part et d'autre de l'axe vertical pour le type 1, et dans un angle de 180° de part et d'autre de l'axe vertical pour les types 2 et 3.

  Le rayon maximal admissible des tubes oscillants de types 1 et 2 est de 1 600 mm. Pour les tubes oscillants de type 3, le rayon ne doit pas être supérieur à 800 mm. Le rayon doit être choisi de sorte que l'espace libre entre le spécimen et l'intérieur du tube ne soit pas supérieur à 200 mm.

  La relation entre le nombre de buses ayant chacune un débit moyen de 0,07 l/min ou 0,6 l/min et le débit total est donnée dans le Tableau 2.

  Un dispositif adapté est représenté à la Figure D.1.

- Support de fixation du spécimen

  Le support de fixation doit simuler, dans toute la mesure du possible, la structure du montage à utiliser dans les conditions réelles d'utilisation des produits. Par exemple, pour un appareil mural, le support de fixation doit simuler le mur.

- Support du spécimen

  Le support du spécimen ne doit pas être perforé pour le type 1 et doit être correctement perforé pour les types 2 et 3.

- Alimentation en eau avec dispositifs de commande

  L'eau utilisée pour l'essai doit être de l'eau douce du robinet, de bonne qualité. Pour éviter l'obturation des buses, l'eau doit être filtrée et peut être déminéralisée. Les caractéristiques de l'eau sont données dans l'Annexe A. Pendant l'essai, la température de l'eau ne doit pas varier de plus de 5 K par rapport à la température du spécimen en essai. Si la température de l'eau est inférieure de plus de 5 K à la température du spécimen, un rééquilibrage en pression doit être réalisé pour le spécimen.

6.2.2.2 Sévérités

Les sévérités telles que l'angle de la buse, le débit d'eau par trou, l'angle du tube oscillant et la durée d'essai doivent être précisées dans la spécification particulière. Les valeurs doivent être choisies parmi celles indiquées ci-dessous.

Toutes les combinaisons de sévérités de l'essai à l'eau peuvent être choisies indépendamment. Dans ce cas, ces combinaisons doivent être indiquées dans la spécification particulière.

Tube de type 1

- Angle de la buse α, degrés ±60
- Débit d'eau par trou, l/min 0,07 (1 ± 5 %)
- Angle du tube oscillant β, degrés ±60
- Durée, min 2 × 5

Tube de type 2

- Angle de la buse α, degrés ±90
- Débit d'eau par trou, l/min 0,07 (1 ± 5) %
- Angle du tube oscillant β, degrés ±180 (environ)
- Durée, min 10, 30, 60

Tube de type 3

- Angle de la buse α, degrés ±90
- Débit d'eau par trou, l/min 0,6 ± 0,03
- Angle du tube oscillant β, degrés ±180 (environ)
- Durée, min 2 × 5

Dans certains cas, la spécification particulière peut préciser une durée plus longue.

6.2.2.3 Préconditionnement

Un préconditionnement du spécimen et des joints d'étanchéité doit être réalisé s'il est précisé dans la spécification particulière.

6.2.2.4 Mesures initiales

Le spécimen doit être soumis aux vérifications visuelles, dimensionnelles et fonctionnelles précisées dans la spécification particulière. Toutes les particularités du spécimen susceptibles d'affecter les résultats des essais, par exemple le traitement de surface, les couvercles et les joints d'étanchéité, doivent être examinées pour s'assurer que les instructions de la spécification particulière ont bien été respectées.

6.2.2.5 Essais

Trois types sont décrits:

Type 1:

Le spécimen à soumettre à l'essai doit être fixé au support de fixation, si cela est spécifié, et doit être placé sur le support dans sa position normale d'utilisation. Pour cet essai, le support ne doit pas être perforé. On doit choisir un tube oscillant comme celui décrit à la Figure D.1, avec des buses réparties sur un arc de 60° de part et d'autre de l'axe vertical et ayant un rayon satisfaisant aux exigences dimensionnelles du spécimen en essai. Le rayon maximal est de 1 600 mm. Si le spécimen en essai est trop grand, l'essai avec la pomme d'arrosoir doit être réalisé. Le tube est pivoté de 60° de part et d'autre de l'axe vertical. La durée d'une oscillation complète allant de +60° à –60°, puis à +60° doit être de 4 s environ.

Le débit d'eau doit être réglé selon les exigences indiquées au Tableau 1.

La durée de l'essai doit être de 5 min.

Le spécimen en essai doit pivoter de 90° dans un plan horizontal et l'essai doit être poursuivi pendant encore 5 min.

S'il n'est pas possible de mouiller toutes les parties du spécimen en essai, le support doit être basculé de haut en bas, ou l'essai avec la pomme d'arrosoir doit être réalisé.

La spécification particulière doit indiquer si le spécimen doit être mis en fonctionnement pendant l'essai et si des mesures intermédiaires doivent être réalisées.

Des mesures de sécurité appropriées doivent être prises lors des essais sous tension.

Tableau 1 – Tube oscillant – Relation entre le nombre de buses et le débit total d'eau par rapport au rayon du tube

	Type 1		Type 2		Type 3	
Rayon R du tube	Nombre de buses ouvertes	Débit total d'eau	Nombre de buses ouvertes	Débit total d'eau	Nombre de buses ouvertes	Débit total d'eau
mm	N[a]	l/min	N[a]	l/min	N[a]	l/min
200	8	0,56	12	0,84	12	7,2
400	16	1,1	25	1,8	25	15,0
600	25	1,8	37	2,6	37	22,2
800	33	2,3	50	3,5	50	30,0
1 000	41	2,9	62	4,3	–	–
1 200	50	3,5	75	5,3	–	–
1 400	58	4,1	87	6,1		–
1 600	67	4,7	100	7,0	–	–

[a] Selon la disposition réelle du centre des buses, pour une distance spécifiée, le nombre N de buses ouvertes peut être augmenté de 1.

Type 2:

L'essai est le même que pour le type 1 avec les différences suivantes:

- le support doit être perforé sauf indication contraire dans la spécification particulière;
- le tube oscillant doit être équipé de buses réparties sur un arc de 90° de part et d'autre de l'axe vertical;
- le tube doit osciller dans un angle d'environ 360°, 180° de part et d'autre de l'axe vertical;
- la durée d'une oscillation complète, de +180° à –180° puis à +180°, doit être de 12 s environ;
- la durée de l'essai doit être choisie conformément à 6.2.2.2;
- le spécimen en essai ne pivote pas de 90° dans un plan horizontal et l'essai est interrompu;
- la spécification particulière doit spécifier l'orientation si elle affecte la sévérité du test.

La spécification particulière doit indiquer si le spécimen doit être mis en fonctionnement pendant les essais et si des mesures intermédiaires doivent être réalisées.

Des mesures de sécurité appropriées doivent être prises lors des essais sous tension.

Type 3:

L'essai est le même que pour le type 2, avec les différences suivantes:

- la durée de l'essai est de 2 × 5 min, c'est-à-dire qu'après 5 min d'essai, le spécimen est pivoté de 90° sur un plan horizontal et l'essai est poursuivi pendant encore 5 min.

La spécification particulière doit indiquer si le spécimen doit fonctionner pendant les essais et si des mesures intermédiaires doivent être réalisées.

Des mesures de sécurité appropriées doivent être prises lors des essais sous tension.

6.2.2.6 Reprise

Sauf exigences contraires dans la spécification particulière, le spécimen doit être soigneusement séché extérieurement en l'essuyant ou en lui appliquant une circulation d'air forcé de faible intensité à la température ambiante.

6.2.2.7 Mesures finales

Le spécimen doit être examiné pour vérifier s'il y a eu pénétration d'eau et doit être soumis aux vérifications visuelles, dimensionnelles et fonctionnelles précisées dans la spécification particulière.

Toute pénétration d'eau doit, lorsque cela est possible, être quantifiée et notée.

6.2.2.8 Informations à fournir dans la spécification particulière

Si cet essai est inclus dans la spécification particulière, les informations suivantes doivent être fournies dans la mesure où elles sont applicables. La spécification particulière doit donner les informations exigées dans les articles indiqués ci-dessous, en prêtant une attention particulière aux points marqués d'un astérisque (*), symbole indiquant qu'une information est toujours exigée.

	Paragraphe
a) Sévérités*	6.2.2.2
b) Préconditionnement	6.2.2.3
c) Mesures initiales*	6.2.2.4
d) Montage du spécimen*	6.2.2.5
e) La ou les positions du spécimen au cours des essais*	6.2.2.5
f) État du spécimen pendant les essais*	6.2.2.5
g) Mesures intermédiaires	6.2.2.5
h) Reprise	6.2.2.6
i) Mesures finales*	6.2.2.7

6.2.3 Méthode Rb 1.2: pomme d'arrosoir

6.2.3.1 Dispositif d'essai

Les exigences fondamentales du dispositif d'essai sont les suivantes:

- Pomme d'arrosoir (également désignée appareil d'arrosage portatif)

  Une pomme d'arrosoir avec un cône de pulvérisation de 78° et un masque mobile à contrepoids qui peut diminuer jusqu'à 30°, à partir de l'horizontale, la partie supérieure du cône de pulvérisation. Le masque peut être retiré comme spécifié. La pomme d'arrosoir doit avoir un débit de 10 l/min ± 5 %, ce qui nécessite une pression d'eau comprise entre 50 kPa et 150 kPa (entre 0,5 bar et 1,5 bar) (voir la Figure D.3).

- Support de fixation du spécimen

  Le support de fixation doit simuler, dans toute la mesure du possible, la structure de montage à utiliser dans les conditions réelles d'utilisation des produits. Par exemple, pour un appareil mural, le support de fixation doit simuler un mur.

- Support du spécimen

  Le support du spécimen doit avoir une surface de base plus petite que la surface de base du spécimen ou doit être correctement perforé.

- Alimentation en eau avec dispositifs de commande

Une fois stabilisée, l'alimentation en eau doit pouvoir fournir au moins un débit de 10 l/min. L'eau utilisée pour l'essai doit être de l'eau douce du robinet, de bonne qualité. Afin d'éviter l'obturation des buses, l'eau doit être filtrée et peut être déminéralisée. Les caractéristiques de l'eau sont détaillées à l'Annexe A. Pendant l'essai, la température de l'eau ne doit pas varier de plus de 5 K par rapport à la température du spécimen en essai. Si la température de l'eau est inférieure de plus de 5 K à la température du spécimen, un rééquilibrage en pression doit être réalisé pour le spécimen.

6.2.3.2 Sévérités

Les surfaces du spécimen à arroser, si ce n'est pas la totalité, doivent être spécifiées. Les sévérités telles que l'utilisation ou la non-utilisation du masque ainsi que la durée de l'essai doivent être précisées dans la spécification particulière. Les sévérités doivent être choisies parmi celles indiquées ci-dessous.

- Masque mobile: utilisé, retiré.
- Durée d'essai, en min/m^2 de surface d'essai, calculée avec une tolérance de ± 10 % (avec une durée minimale, min)

  1 (5); 3 (15); 6 (30).

Dans certains cas, la spécification particulière peut préciser une durée plus longue.

6.2.3.3 Préconditionnement

Un préconditionnement du spécimen et des joints d'étanchéité doit être effectué s'il est précisé dans la spécification particulière.

6.2.3.4 Mesures initiales

Le spécimen doit être soumis aux vérifications visuelles, dimensionnelles et fonctionnelles précisées dans la spécification particulière. Toutes les particularités du spécimen susceptibles d'affecter les résultats d'essai, par exemple le traitement de surface, les couvercles ou le joint d'étanchéité, doivent être examinés pour s'assurer que les instructions de la spécification particulière ont bien été respectées.

6.2.3.5 Essais

Le spécimen doit être monté comme cela est décrit par la procédure d'essai du tube oscillant (type 1 ou type 2 de 6.2.2.5). La pression de l'eau doit être réglée pour obtenir un débit de 10 (1 ± 5 %) l/min. Elle doit être maintenue constante tout au long de l'essai. Les surfaces spécifiées doivent être arrosées pendant la durée spécifiée et depuis une distance de (0,4 ± 0,1) m. Si la buse est utilisée à la place du tube oscillant de type 2, le masque mobile doit être retiré et la pulvérisation doit être appliquée selon un angle de ±180° par rapport à l'axe vertical.

La spécification particulière doit indiquer si le spécimen doit être mis en fonctionnement pendant l'essai et si des mesures intermédiaires doivent être réalisées.

Des mesures de sécurité appropriées doivent être prises pendant les essais sous tension.

6.2.3.6 Reprise

Sauf exigences contraires dans la spécification particulière, le spécimen doit être soigneusement séché extérieurement en l'essuyant ou en lui appliquant une circulation d'air forcé de faible intensité à la température ambiante.

6.2.3.7 Mesures finales

Le spécimen doit être examiné pour vérifier s'il y a eu pénétration d'eau et doit être soumis aux vérifications visuelles, dimensionnelles et fonctionnelles précisées dans la spécification particulière.

Toute pénétration d'eau doit, lorsque cela est possible, être quantifiée et notée.

6.2.3.8 Informations à fournir dans la spécification particulière

Si cet essai est inclus dans la spécification particulière, les informations suivantes doivent être fournies dans la mesure où elles sont applicables. La spécification particulière doit donner les informations exigées dans les paragraphes indiqués ci-dessous, en prêtant une attention particulière aux points marqués d'un astérisque (*), symbole indiquant qu'une information est toujours exigée.

		Paragraphe
a)	Sévérités*	6.2.3.2
b)	Préconditionnement	6.2.3.3
c)	Mesures initiales*	6.2.3.4
d)	Montage du spécimen*	6.2.3.5
e)	La ou les positions du spécimen au cours des essais*	6.2.3.5
f)	État du spécimen pendant les essais*	6.2.3.5
g)	Mesures intermédiaires	6.2.3.5
h)	Reprise	6.2.3.6
i)	Mesures finales*	6.2.3.7

6.3 Méthode Rb 2: jet d'eau

6.3.1 Description générale de l'essai

Le spécimen en essai est fixé sur un support de fixation. Il convient de soumettre le spécimen en essai à un jet d'eau qui simule des éclaboussures provenant des roues, ou des paquets de mer. La buse d'essai normalisée est décrite en D.2.2 et à la Figure D.4.

Les exigences fondamentales du dispositif d'essai sont:

- Buse d'arrosage

  La buse d'arrosage doit fournir un jet d'eau bien formé et avoir un diamètre utile, respectivement, de 6,3 mm et 12,5 mm pour la petite buse et la grande buse (voir Figure D.4).

- Support de fixation du spécimen

  Le support de fixation doit, dans toute la mesure du possible, simuler la structure de montage à utiliser dans les conditions réelles d'utilisation des produits. Par exemple, pour un appareil mural, le support de fixation doit simuler un mur.

  Le support de fixation du spécimen doit avoir une surface de base plus petite que celle du spécimen ou être convenablement perforé.

  Le support de fixation doit avoir une résistance et une stabilité suffisantes pour supporter les effets hydrodynamiques du jet d'eau.

- Alimentation en eau avec commandes

  L'eau utilisée pour l'essai doit être de l'eau douce du robinet, de bonne qualité et doit pouvoir être fournie à un débit d'au moins 100 l/min. Il convient que la pression de l'eau