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INTERNATIONAL STANDARD

Environmental testing –
Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads

IEC 60068-2-20:2008(E)

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FOREWORD

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International Standard IEC 60068-2-20 has been prepared by IEC technical committee 91: Electronics assembly technology.

This fifth edition cancels and replaces the fourth edition, published in 1979 and its Amendment 2 (1987). Amendment 2 includes Amendment 1. This fifth edition constitutes a technical revision and includes test conditions and requirements for use of lead-free solder.

The major technical changes with regard to the fourth edition are the following:

– the solder globule test is deleted;
– test conditions and requirements for lead-free solders are added.

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

FDIS	Report on voting
91/764/FDIS	91/774/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 the parts in the IEC 60068 series, 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 maintenance result date indicated on the IEC web site 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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

ENVIRONMENTAL TESTING –

Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads

1 Scope and object

This part of IEC 60068 outlines Test T, applicable to devices with leads. Soldering tests for surface mounting devices (SMD) are described in IEC 60068-2-58.

This standard provides procedures for determining the solderability and resistance to soldering heat of devices in applications using solder alloys, which are eutectic or near eutectic tin lead (Pb), or lead-free alloys.

The procedures in this standard include the solder bath method and soldering iron method.

The objective of this standard is to ensure that component lead or termination solderability meets the applicable solder joint requirements of IEC 61191-3 and IEC 61191-4. In addition, test methods are provided to ensure that the component body can resist against the heat load to which it is exposed during soldering.

NOTE Information about wetting time and wetting force can be obtained by test methods using a wetting balance. See IEC 60068-2-54 (solder bath method) and IEC 60068-2-69 (solder bath and solder globule method for SMDs).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-2, *Environmental testing – Part 2-2: Tests – Tests B: Dry heat*

IEC 60068-2-66, *Environmental testing – Part 2-66: Test methods: Test Cx: Damp heat, steady state (unsaturated pressurized vapour)*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady State*

IEC 60194, *Printed board design, manufacture and assembly – Terms and definitions*

IEC 61191-3, *Printed board assemblies – Part 3: Sectional specification – Requirements for through-hole mount soldered assemblies*

IEC 61191-4, *Printed board assemblies – Part 4: Sectional specification – Requirements for terminal soldered assemblies*

3 Terms and definitions

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

3.1
colophony
natural resin obtained as the residue after removal of turpentine from the oleo-resin of the pine tree, consisting mainly of abietic acid and related resin acids, the remainder being resin acid esters

NOTE "Rosin" is a synonym for colophony, and is deprecated because of the common confusion with the generic term "resin".

3.2
contact angle
in general the angle enclosed between two planes, tangent to a liquid surface and a solid/liquid interface at their intersection (see Figure 1). In particular the contact angle of liquid solder in contact with a solid metal surface

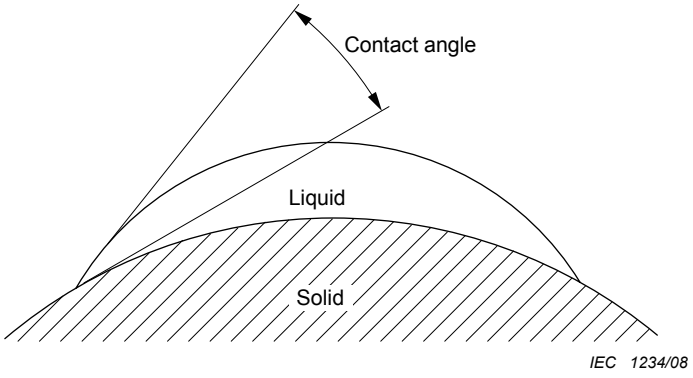


Figure 1 – Diagram of contact angle

3.3
wetting
formation of an adherent coating of solder on a surface. A small contact angle is indicative of wetting

3.4
non-wetting
inability to form an adherent coating of solder on a surface. In this case the contact angle is greater than 90°

3.5
de-wetting
retraction of molten solder on a solid area that it has initially wetted

NOTE In some cases an extremely thin film of solder may remain. As the solder retracts the contact angle increases.

3.6
solderability
ability of the termination or lead of device to be wetted by solder at the temperature of the termination or lead which is assumed to be the lowest temperature in the soldering process within solderable temperature of solder alloy

3.7
soldering time
time required for a defined surface area to be wetted under specific conditions

3.8
resistance to soldering heat
ability of device to withstand the highest temperature of the termination or lead in soldering process, within applicable temperature range of solder alloy

3.9
lead-free solder
alloy that does not contain more than 0,1 % lead (Pb) by weight as its constituent and is used for joining components to substrates or for coating surfaces

[75.1904 of IEC 60194]

4 Test Ta: Solderability of wire and tag terminations

4.1 Object and general description of the test

4.1.1 Test methods

Test Ta provides two different test methods to determine the solderability of the areas on wire and tag terminations that are required to be wetted by solder.

– Method 1: Solder bath
– Method 2: Soldering iron

The test method to be used shall be indicated in the relevant specification. The solder bath method is the one which simulates most closely the soldering procedures of flow soldering and similar soldering processes.

The soldering iron method may be used in cases where Method 1 is impracticable.

If required by the relevant specification, the test conditioning may be preceded by accelerated ageing. The following are recommended conditions:

Ageing 1a: 1 h steam ageing

Ageing 1b: 4 h steam ageing

Ageing 2: 10 days damp heat, steady state condition (40 ± 2) °C; (93 ± 3) % RH (Test Cab)

Ageing 3a: 4 h at 155 °C dry heat (Test Bb)

Ageing 3b: 16 h at 155 °C dry heat (Test Bb).

Ageing 4: 4 h unsaturated pressurized vapour (Test Cx)

NOTE The test specimens may be introduced into the chamber at any temperature from laboratory temperature to the specified temperature.

4.1.2 Specimen preparation

The surface to be tested shall be in the "as received" condition and shall not be subsequently touched by the fingers or otherwise contaminated.

The specimen shall not be cleaned prior to the application of a solderability test. If required by the relevant specification, the specimen may be degreased by immersion in a neutral organic solvent at room temperature.

4.1.3 Initial measurements

The specimens shall be visually examined and, if required by the relevant specification, electrically and mechanically checked.

4.1.4 Accelerated ageing

If accelerated ageing is required by the relevant specification, one of the following procedures shall be adopted. At the end of the conditioning, the specimen shall be subjected to standard atmospheric conditions for testing for not less than 2 h and not more than 24 h.

NOTE Terminations may be detached if the ageing temperature is higher than the component's maximum operating or storage temperature, or if the component is likely to degrade considerably at 100 °C in steam and thus affect the solderability in a manner which would not normally occur in natural ageing.

4.1.4.1 Ageing 1

The relevant specification shall indicate whether ageing 1a (1 h in steam) or ageing 1b (4 h in steam) is to be used. For these procedures the specimen is suspended, preferably with the termination vertical, with the area to be tested positioned 25 mm to 30 mm above the surface of boiling distilled water which is contained in a borosilicate glass or stainless steel vessel of suitable size (e.g., a 2 litre beaker). The termination shall be not less than 10 mm from the walls of the vessel.

The vessel shall be provided with a cover of like material consisting of one or more plates which are capable of covering approximately seven-eighths of the opening. A suitable method of suspending the specimens shall be devised; perforations or slots in the cover are permitted for this purpose. The specimen holder shall be non-metallic.

The level of water shall be maintained by the addition of hot distilled water, added gradually in small quantities, so that the water will continue to boil vigorously; alternatively a reflux condenser may be provided if desired. (See Figure A.1).

4.1.4.2 Ageing 2

Specimens are subjected to 10 days damp heat, steady state, according to IEC 60068-2-78, Test Ca: Damp heat, steady state.

4.1.4.3 Ageing 3

Specimens are subjected to 4 h (Ageing 3a) or 16 h (Ageing 3b) dry heat at 155 °C according to IEC 60068-2-2, Test B: Dry heat.

4.1.4.4 Ageing 4

Specimens are subjected to 4 h at 120 °C and 85 % RH according to IEC 60068-2-66, Test Cx: Damp heat, steady state (unsaturated pressurized vapour).

4.2 Method 1: Solder bath

This method provides a procedure for assessing the solderability of wires, tags, and terminations of irregular form.

4.2.1 Description of the solder bath

The solder bath shall be not less than 40 mm in depth and not less than 300 ml in volume. The bath shall contain solder as specified in Table 1.

4.2.2 Flux

The flux to be used shall consist of 25 % by weight of colophony in 75 % by weight of 2-propanol (isopropanol) or of ethyl alcohol, as specified in Annex B.

When non-activated flux is inappropriate, the above flux with the addition of diethylammonium chloride (analytical reagent grade), up to an amount of 0,2 % chloride (expressed as free chlorine based on the colophony content), may be used as required by the relevant specification.

4.2.3 Procedure

The surface of the molten solder shall be wiped clean and bright with a piece of suitable material immediately before each test.

The termination to be tested shall be immersed first in the flux described in 4.2.2 at laboratory temperature, and excess flux shall be eliminated either by draining off for a suitable time, or by using any other procedure likely to produce a similar result. In case of dispute, drainage shall be carried out for (60 ± 5) s.

NOTE Excessive remaining flux may boil when coming into contact with the liquid solder. Gas bubbles may stick to the surface of terminations and prevent wetting of the termination in the respective area.

The termination is then immersed immediately in the solder bath in the direction of its longitudinal axis. The point of immersion of the termination shall be at a distance not less than 10 mm from the walls of the bath.

The speed of immersion shall be (25 ± 2,5) mm/s and the termination shall remain immersed for the time selected from Table 1 with the body of the component at the distance above the solder prescribed in the relevant specification. The specimen shall then be withdrawn at (25 ± 2,5) mm/s.

For components having a high thermal capacity an immersion time of (5,0 ± 0,5) s or (10 ± 1) s may be selected from Table 1.

If required by the relevant specification, a screen of thermally insulating material of (1,5 ± 0,5) mm thickness with clearance, holes appropriate to the size of the termination may be placed between the body of the component and solder.

Any flux residue shall be removed with 2-propanol (isopropanol) or ethyl alcohol.

4.2.4 Test conditions

The duration and temperature of immersion shall be selected from Table 1, unless otherwise prescribed by the relevant specification.

Table 1 – Solderability, solder bath method: Test severities (duration and temperature)

Alloy composition	Severity					
	(215 ± 3) °C (3 ± 0,3) s	(10 ± 1) s	(235 ± 3) °C (2 ± 0,2) s	(5 ± 0,5) s	(245 ± 3) °C (3 ± 0,3) s	(250± 3) °C (3 ± 0,3) s
SnPb	X	X	X	X		
Sn96,5Ag3Cu,5					X	
Sn99,3Cu,7						X
Alloy composition for test purposes only. The solder alloys consist of 3,0 wt % to 4,0 wt % Ag, 0,5 wt % to 1,0 wt % Cu, and the remainder of Sn may be used instead of Sn96,5Ag3Cu,5. The solder alloys consist of 0,45 wt % to 0,9 wt % Cu and the remainder of Sn may be used instead of Sn99,3Cu,7.						
NOTE 1 "X" denotes 'applicable'. NOTE 2 Refer to 4.1 of IEC 61190-1-3 to identify alloy composition. NOTE 3 The basic lead-free solder alloys listed in this table represent compositions that are currently preferred for lead-free soldering processes. If solder alloys other than those listed here are used, it has to be verified that the given severities are applicable.						

4.2.5 Final measurements and requirements

Inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 x to 25 x, depending on the size of objects.

The specimens shall be visually examined and, if required by the relevant specification, electrically and mechanically checked.

The dipped surface relevant for soldering shall be covered with solder coating with no more than small amounts of scattered imperfections such as pin-holes or un-wetted or de-wetted areas. All leads shall exhibit a continuous solder coating free from defects for a minimum of 95% of the critical area of any individual lead. For solder alloys containing lead, solder shall be smooth and bright.

4.3 Method 2: Soldering iron at 350 °C

This method provides a procedure for assessing the solderability of terminations in cases where the solder bath method is impracticable. It applies to lead containing and lead-free solder alloys.

4.3.1 Description of soldering irons

To keep the bit temperature during test within the specified limits, usage of a temperature controlled soldering iron is recommended.

Size A

Bit temperature: (350 ± 10) °C

Bit diameter: 8 mm

Exposed length: 32 mm reduced to a wedge shape over a length of approximately 10 mm.

Size B

Bit temperature: (350 ± 10) °C

Bit diameter: 3 mm

Exposed length: 12 mm reduced to a wedge shape over a length of approximately 5 mm.

The bit shall be made of copper, preferably plated with iron, or of erosion-resistant copper alloy, in accordance with usual practice, and tinned at the test surface.

4.3.2 Solder and flux

A cored solder wire shall be used comprising solder as specified in Table 1 with a core or cores containing 2,5 % to 3,5 % colophony as specified in Annex B. A visual check shall be made during the test for the presence of flux.

4.3.3 Procedure

According to the type of component, an iron of either Size A or Size B shall be used as prescribed in the relevant specification.

The nominal diameter of the solder wire to be used with Size A iron is 1,2 mm and 0,8 mm with Size B iron.

The termination shall be positioned so that the iron can be applied to the test surface in a horizontal position as in Figure 2.

If mechanical support for the terminations be required while performing this test, such support shall be of thermally insulating material.

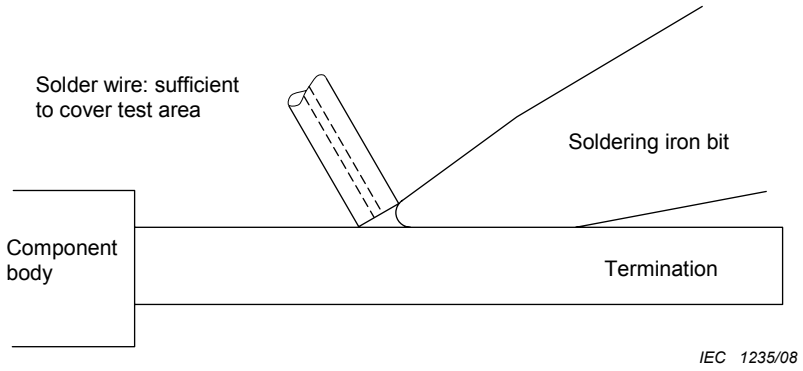


Figure 2 – Position of soldering iron

When testing heat-sensitive components, the relevant specification shall specify the distance of the test area from the component body, or it shall specify the use of a specific heat sink.

The relevant specification may specify different conditions where the geometry of the terminations renders the above procedure impracticable.

Surplus solder which has remained on the test surface of the iron from a previous test shall be wiped off.

The iron and the solder shall, unless otherwise specified, be applied to the termination for 2 s to 3 s at the position stated in the relevant specification. During this period of time the iron shall be kept stationary.

If the relevant specification requires that several terminations of the component shall be tested, an interval in the order of 5 s to 10 s shall be observed between the applications to the different terminations of the component to avoid it being overheated.

Any flux residue shall be removed from the terminations with 2-propanol (isopropanol) or with ethyl alcohol.

4.3.4 Final measurements and requirements

Inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 x to 25 x, depending on the size of objects.

The specimens shall be visually examined and, if required by the relevant specification, electrically and mechanically checked.

The solder shall have wetted the test area and there shall be no droplets.

4.4 Information to be given in the relevant specification

When this test is included in the relevant specification, the following details shall be given as far as they are applicable.

		Subclause
a)	Whether degreasing is required	4.1.2
b)	Initial measurements	4.1.3
c)	Ageing method (if required)	4.1.4
d)	Test method	4.2 or 4.3
e)	Whether activated flux shall be used	4.2.2
f)	Immersion depth, temperature and duration	4.2.3, 4.2.4
g)	Whether a thermal screen is to be used	4.2.3
h)	Size of soldering iron (A or B)	4.3.1
i)	Distance of test area from component body or use of a heat sink	4.3.3
j)	Different test conditions, if required by geometry of termination	4.3.3
k)	Position of the soldering iron	4.3.3
l)	Application time of soldering iron, if not 2 s to 3 s	4.3.3
m)	Number of terminations to be tested	4.3.3
n)	Final measurements and requirements	4.3.4
o)	Type of solder alloy	Table 1, 4.3.2

5 Test Tb: Resistance to soldering heat

5.1 Object and general description of the test

5.1.1 Test methods

Test Tb provides two different methods to determine the ability of a specimen to withstand the heating stresses produced by soldering.

– Method 1: Solder bath

– Method 2: Soldering iron

Method 1 is identical to Test Ta, Method 1, but with different immersion times and temperatures.

Method 2 is identical to Test Ta, Method 2, but with the iron applied to the test surface for 10 s.

5.1.2 Initial measurements

The specimens shall be visually examined and electrically and mechanically checked as required by the relevant specification.

5.2 Method 1: Solder bath

5.2.1 Description of the solder bath

The solder bath shall be not less than 40 mm in depth and not less than 300 ml in volume. The bath shall contain solder as specified in Table 2.

5.2.2 Flux

The flux to be used shall consist of 25 % by weight of colophony in 75 % by weight of 2-propanol (isopropanol) or of ethyl alcohol, as specified in Annex B.

When non-activated flux is inappropriate, the above flux with the addition of diethylammonium chloride (analytical reagent grade), up to an amount of 0,5 % chloride (expressed as free chlorine based on the colophony content), may be used as required by the relevant specification.

When the test forms part of a test sequence and is applied prior to a humidity test, a non-activated flux comprising 25 % by weight of colophony in 75 % by weight 2-propanol (isopropanol) or ethyl alcohol shall be used. In this case, the test shall be made on specimens which have a surface which has satisfactorily passed the solderability Test Ta, Method 1, within the previous 72 h period.

5.2.3 Procedure

The surface of the molten solder shall be wiped clean and bright by wiping with a piece of suitable material immediately before each test.

The termination to be tested shall be immersed first in the flux described in 5.2.2 at laboratory temperature, and then in the solder bath, in the direction of its longitudinal axis. The point of immersion of the termination shall be at a distance not less than 10 mm from the walls of the bath.

Immersion of the termination to within 2,0 mm to 2,5 mm from the component or seating plane, unless otherwise specified in the relevant specification, shall be completed in a time not exceeding 1 s.

The termination shall remain immersed to the specified depth for one of the durations given in Table 2, or as prescribed in the relevant specification.

5.2.4 Test conditions

The duration and temperature of immersion shall be selected from Table 2, unless otherwise prescribed by the relevant specification.

Table 2 – Resistance to soldering heat, solder bath method: Test severities (duration and temperature)

Alloy composition	Severity		
	(235 ± 3) °C (10 ± 1) s	(260± 3) °C (5 ± 0,5) s	(260± 3) °C (10 ± 1) s
SnPb	X	X[b]	X[c]
Lead-free alloy [a]		X[b]	X[c]

NOTE 1 "X" denotes 'applicable.

NOTE 2 Certain soldering methods may require higher severity of (270± 3) °C for (5 ± 0,5) s or the more severe condition of (10 ± 1) s. Such conditions should be provided by the detail specification as agreed between the trading partners.

NOTE 3 Care should be taken, that heat / moisture sensitive devices are handled according to the instructions of the supplier.

[a] Any alloys may be used, provided they are completely liquid at the required temperature.

[b] The shorter immersion time of 5 s is mainly intended for heat-sensitive components to be mounted on printed circuits. A warning should be given to the user that such components should be soldered to the printed circuit board in less than 4 s.

[c] This test severity is also used for the De-wetting test. As an optional test condition (260 ± 5) °C for (30 ± 3) s is also used.

Unless otherwise prescribed in the relevant specification, a screen of thermally insulating material of (1,5 ± 0,5) mm thickness, with clearance holes appropriate to the size of the termination, shall be placed between the body of the component and the molten solder.

When the relevant specification prescribes the use of a heat sink during this test, it shall give full details of the size and type of heat sink to be used, which should be related to the method used for production soldering.

5.2.5 De-wetting

The relevant specification shall prescribe whether this test is required.

A total immersion of 10 s is required because de-wetting can occur slowly; this immersion shall be divided into two periods of 5 s each in order that any rapid de-wetting is not masked by any subsequent re-wetting.

5.3 Method 2: Soldering iron

5.3.1 Description of soldering iron

As prescribed in 4.3.1.

The relevant specification shall state whether iron A or iron B is to be used.

5.3.2 Solder and flux

As prescribed in 4.3.2.

5.3.3 Procedure

As prescribed in 4.3.3 (Method 2, with the soldering iron of Test Ta), but with the iron applied to the test surface of the termination for one of the following temperatures and durations, as prescribed in the relevant specification.

Temperature: 350 °C or 370 °C

Duration: (5 ± 1) s or
(10 ± 1) s

If the relevant specification does not indicate the duration, 10 s shall apply.

NOTE In testing certain types of electromechanical and other heat-sensitive components, prolonged heat stress may provoke non-repairable defects. The usual soldering times used in practice are in the range of 1 s to 2 s; this and the heat sensitivity of the component should be considered when selecting the test duration. Additional precautions (e.g. automatic switching off of the heat source) may be necessary.

For heat-sensitive components, the relevant specification shall specify the distance of the test area from the component body, or shall specify the use of a specific heat sink.

If the relevant specification requires that several terminations of the component shall be tested, an interval in the order of 5 s to 10 s shall be observed between the applications to the different terminations of the component to avoid it being overheated.

5.4 Recovery

The specimen shall remain under standard atmospheric conditions for testing as prescribed in IEC 60068-1 for a period of 30 min, or until thermally stabilized.

NOTE It may occur with certain components, such as some semiconductors and capacitors, that the electrical properties are stabilized only some hours after heat stability is reached.

5.5 Final measurements and requirements

Inspection shall be carried out under adequate light with normal eyesight or with the assistance of a magnifier capable of giving a magnification of 4 x to 25 x, depending on the size of objects.

The specimens shall be visually examined and electrically and mechanically checked, including dimensional tolerances, as required by the relevant specification.

5.6 De-wetting (if required)

The criteria for wetting described in 4.2.5 shall also apply.

If de-wetting or unwetted areas occur this should be noted.

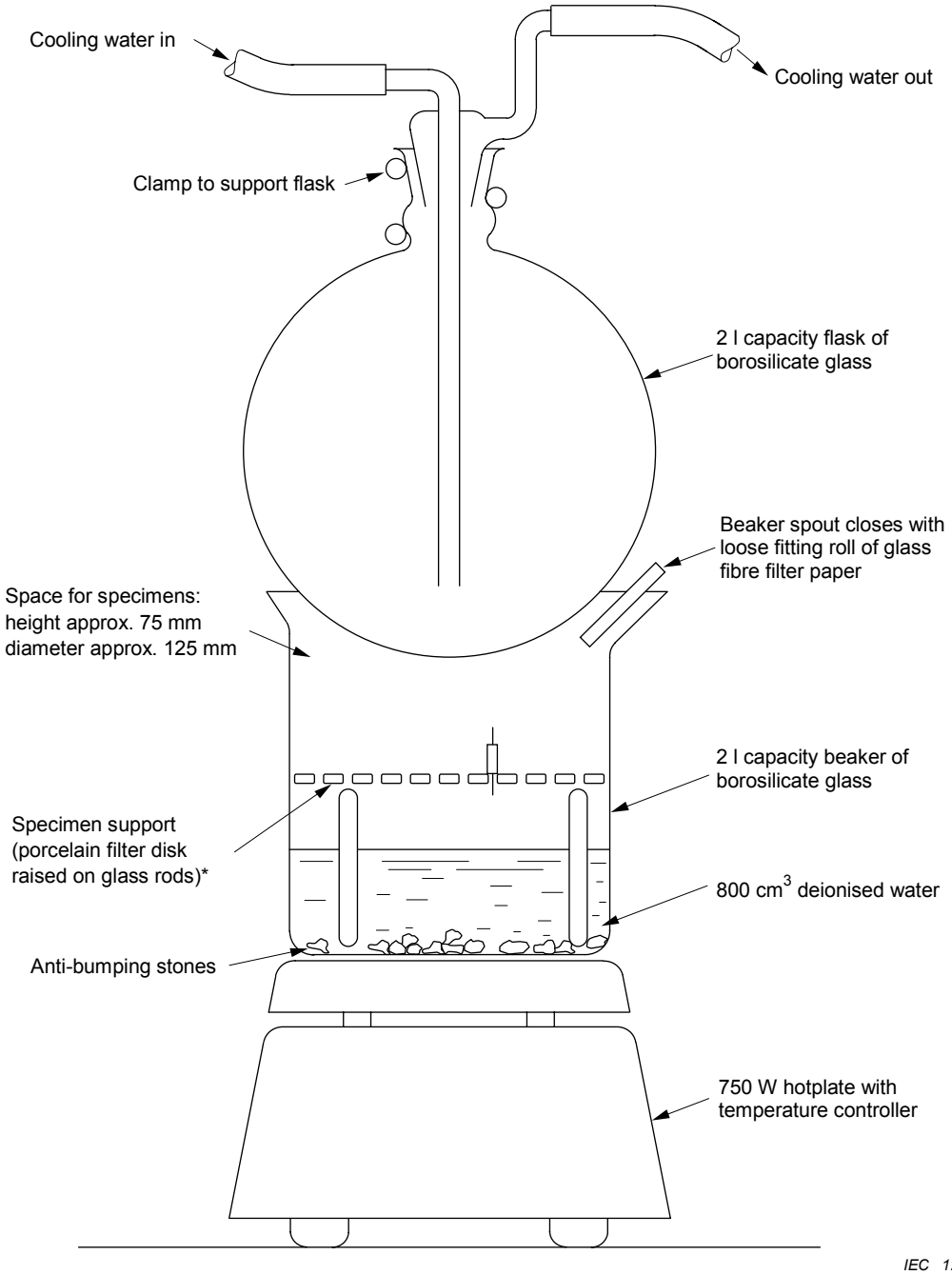
5.7 Information to be given in the relevant specification

When this test is included in the relevant specification, the following details shall be given as far as they are applicable:

		Subclause
a)	Initial measurements	5.1.2
b)	Test method to be applied	5.2; 5.3
c)	Immersion depth, if different from 2,0 mm to 2,5 mm from the component	5.2.3
d)	Test severity	5.2.4
e)	Whether a thermal screen is to be used or not, and details of a heat sink, if required	5.2.4
f)	Whether test De-wetting applies	5.2.5
g)	Size (A or B) of soldering iron	5.3.1
h)	Distance of the test area from the component body or use of a specific heat sink	5.3.3
i)	Number of terminations to be tested	5.3.3
j)	Temperature and duration of the soldering iron test	5.3.3
k)	Type of solder alloy in case de-wetting is tested	Table 2, 5.3.2
l)	Final measurements and requirements	5.5, 5.6

Annex A
(informative)

Example of apparatus for accelerated steam ageing process



NOTE Specimens should not be placed under the lowest portion of the cooling flask because of dripping water.

Figure A.1 – Example of apparatus

Annex B
(normative)

Specification for flux constituents

B.1 Colophony

Colour	To WW grade or paler
Acid value (mg KOH/g colophony)	155 (minimum)
Softening point (ball and ring)	70 °C (minimum)
Flow point (Ubbelohde)	76 °C (minimum)
Ash	0,05 % (maximum)
Solubility	A solution of the colophony in an equal part by weight of 2-propanol (isopropanol) shall be clear, and after a week at room temperature there shall be no sign of a deposit

B.2 2-propanol (isopropanol)

Purity	Minimum 99,5 % 2-propanol (isopropanol) by weight
Acidity as acetic acid (other than carbon dioxide)	Maximum 0,002 % by weight
Non-volatile matter	Maximum 2 mg per 100 ml

B.3 Ethyl alcohol

Purity	Minimum 96,2 % ethyl alcohol by weight
Free acids (other than carbon dioxide)	Maximum 4 mg/l

NOTE When an activated flux is called for this may be conveniently made up as follows:

Colophony	25 g	for 0,5 % chloride activation
2-propanol (isopropanol) or Ethyl alcohol	75 g	
Diethylammonium chloride	0,39 g	

Bibliography

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