

CONSOLIDATED VERSION

VERSION CONSOLIDÉE



Environmental testing –

Part 2-69: Tests – Test Te/Tc: Solderability testing of electronic components and printed boards by the wetting balance (force measurement) method

Essais d'environnement –

Partie 2-69: Essais – Essai Te/Tc: Essai de brasabilité des composants électroniques et cartes imprimées par la méthode de la balance de mouillage (mesure de la force)



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

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

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Environmental testing –

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ENVIRONMENTAL TESTING –

Part 2-69: Tests – Test Te/Tc: Solderability testing of electronic components and printed boards by the wetting balance (force measurement) method

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This Consolidated version of IEC 60068-2-69 bears the edition number 3.1. It consists of the third edition (2017-03) [documents 91/1405/FDIS and 91/1426/RVD] and its corrigendum (2018-01), and its amendment 1 (2019-06) [documents 91/1566/FDIS and 91/1580/RVD]. The technical content is identical to the base edition and its amendment.

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 60068-2-69 has been prepared by IEC technical committee 91: Electronics assembly technology.

This third edition constitutes a technical revision.

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

- integration of IEC 60068-2-54;
- inclusion of tests of printed boards;
- inclusion of new component types, and updating test parameters for the whole component list;
- inclusion of a new gauge R & R test protocol to ensure that the respective wetting balance equipment is correctly calibrated.

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

A list of all 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 the base publication and its amendment will remain unchanged until the stability 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

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ENVIRONMENTAL TESTING –

Part 2-69: Tests – Test Te/Tc: Solderability testing of electronic components and printed boards by the wetting balance (force measurement) method

1 Scope

This part of IEC 60068 outlines test Te/Tc, the solder bath wetting balance method and the solder globule wetting balance method to determine, quantitatively, the solderability of the terminations. Data obtained by these methods are not intended to be used as absolute quantitative data for pass–fail purposes.

The procedures describe the solder bath wetting balance method and the solder globule wetting balance method. They are applicable to components and printed boards with metallic terminations and metallized solder pads.

This document provides the measurement procedures for solder alloys both with and without lead (Pb).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 – Test B: Dry heat*

IEC 60068-2-20:2008, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

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

IEC 61190-1-3:2007, *Attachment materials for electronic assembly – Part 1-3: Requirements for electronic grade solder alloys and fluxed and non-fluxed solid solders for electronic soldering applications*

IEC 61190-1-3:2007/AMD1:2010

ISO 683 (all parts), *Heat-treatable steels, alloy steels and free-cutting steels*

ISO 6362 (all parts), *Wrought aluminium and aluminium alloys – Extruded rods/bars, tubes and profiles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-1 and IEC 60068-2-20 apply.

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

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

4 General description of the method

4.1 General

The user should note that the test method specified in this document is intended to provide consistent and discriminatory data between various test sites. Hence the choice of alloy, temperature and flux shall be controlled.

Using this test method to control a production process is encouraged. However, as each production process will employ different alloys, temperatures and fluxes, such test results shall be agreed upon between user and supplier. In case of a dispute, the procedures of this document shall prevail.

NOTE Information regarding wetting balance for SMD solderability testing is described in Annex B.

4.2 Components

The test specimen shall be a sample from the intended production batch. The test specimen is mounted into a suitable holder that is suspended from a sensitive balance. Liquid flux is then applied to the specimen that is brought into contact with the cleaned surface of the liquid solder within a solder bath, or the apex of a solder globule. The solder in either case is at a controlled temperature, and the lead or termination under test is immersed to the prescribed depth.

4.3 Printed boards

The test specimen should be a representative test specimen, a portion of the printed board being tested, or a whole board if within size limits, such that an immersion depth defined in the individual method is possible. Test specimens may be used for rigid board surface solderability and plated-through-hole solderability.

Liquid flux is then applied to the specimen that is brought into contact with the cleaned surface of a solder bath, or the apex of a solder globule, that is at a controlled temperature and immersed to the prescribed depth.

4.4 Measurement

The resultant forces, measured in mN, of buoyancy and surface tension acting upon the immersed termination are detected by a transducer and converted into a signal that is continuously monitored as a function of time, and recorded and displayed on a computer screen.

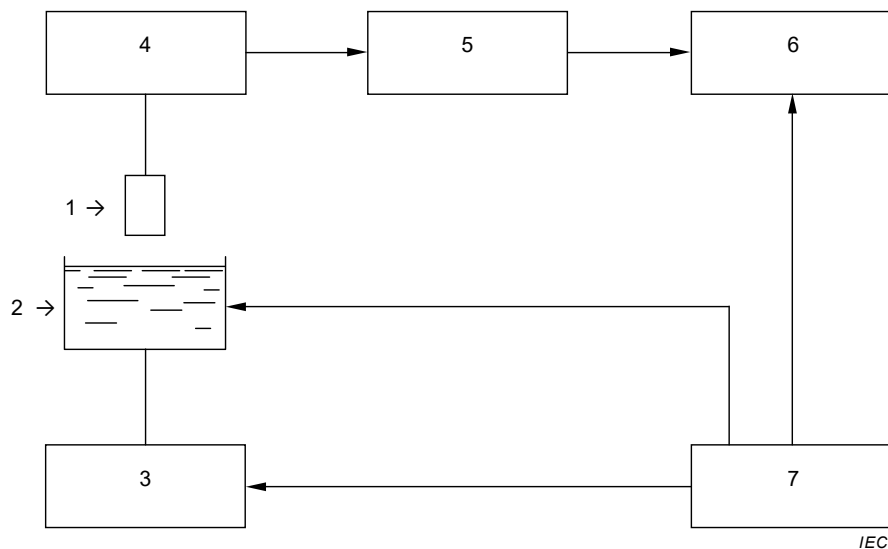
The wetting speed and the extent of wetting are derived from the force against time curve. The trace may be compared with that derived from a perfectly wetted specimen of the same nature and dimensions.

5 Description of the test apparatus

Figure 1 and Figure 2 show a suitable arrangement for the test apparatus.

The apparatus specifications are given in Annex A.

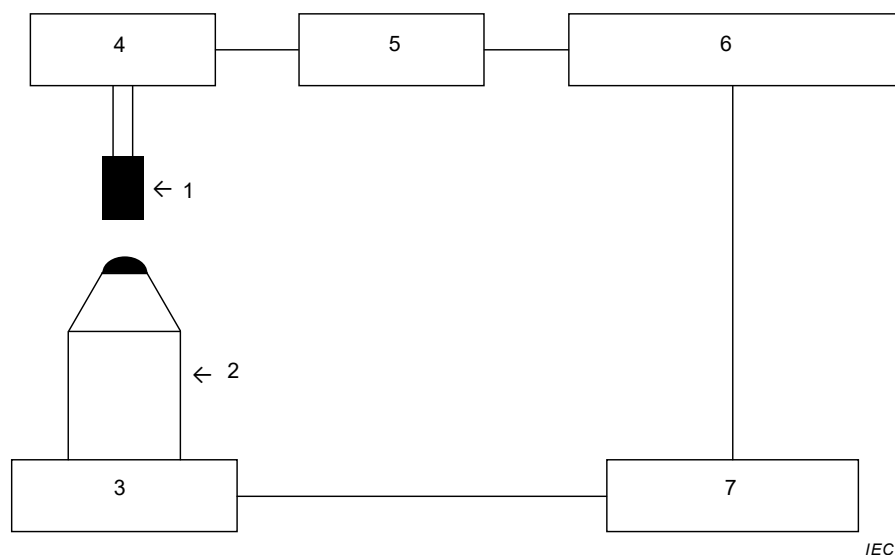
The specimen is suspended from a sensitive balance and a mechanism used to either raise the solder to meet the specimen or lower the specimen into the solder. After conditioning, the transducer signal is passed to a computer, where the force against time curve may be displayed and analysed.



Key

- | | |
|---------------------------------|--------------------------|
| 1 Specimen | 2 Solder bath |
| 3 Solder bath lifting mechanism | 4 Balance and transducer |
| 5 Signal conditioner | 6 Computer |
| 7 Control box | |

Figure 1 – Arrangement for the test apparatus (solder bath wetting balance method)



Key

- | | |
|----------------------|--------------------------|
| 1 Specimen | 2 Globule support block |
| 3 Lift mechanism | 4 Balance and transducer |
| 5 Signal conditioner | 6 Computer |
| 7 Control box | |

Figure 2 – Arrangement for the test apparatus (solder globule wetting balance method)

6 Preparation of specimens

6.1 Cleaning

Unless otherwise specified, the specimen shall be tested in the as-received condition and care should be taken to ensure that no part of the surface to be tested becomes contaminated, particularly by contact with the fingers, during the preparation and handling of the specimen.

If required by the component specification, the specimen may be cleaned by immersion in a neutral organic solvent at room temperature. The specimen should be allowed to dry in air before testing. No other cleaning is permitted.

6.2 Preconditioning

If required by the component specification, the component may be subjected to preconditioning before testing. This shall be performed for 4 h at 155 °C unless otherwise agreed between user and supplier (Table 1, condition F).

In the past, it had been practice to use the term accelerated ageing which, as given in IEC 60068-2-20:2008, 4.1.1, has six alternative conditions that may be used as an alternative if agreed between user and supplier:

- A – ageing 1a of IEC 60068-2-20;
- B – ageing 1b of IEC 60068-2-20;
- C – ageing 1b of IEC 60068-2-20, but for 8 h;
- D – ageing 1b of IEC 60068-2-20, but for 16 h;
- E – ageing 4 of IEC 60068-2-20;
- F – ageing 3a of IEC 60068-2-20.

Refer to Table 1, for preconditioning.

Table 1 – Preconditioning

Condition category	Precondition type	Exposure parameters	Use recommendation	Applicability by finish
A	Steam	1 h ± 5 min	Preferred	Non-tin and non-tin alloy containing finishes
B		4 h ± 10 min	Preferred	Non-tin and non-tin alloy containing finishes
C		8 h ± 15 min	Optional	Non-tin and non-tin alloy containing finishes
D		16 h ± 30 min	Optional	Non-tin and non-tin alloy containing finishes
E	Unsaturated pressurized vapour (120 °C, 85 % RH)	4 h ± 10 min	Preferred	All finishes
F	155 °C dry bake	4 h ± 15 min	Preferred	All finishes

7 Materials

7.1 Solder

7.1.1 General

The solder to be used for both the solder bath and for the solder globule wetting balance test shall be as specified in 7.1.2 or 7.1.3.

7.1.2 Solder alloy containing lead

The solder shall be Sn60Pb40A, Sn63Pb37A or Sn62Pb36Ag02B (refer to the IEC 61190-1-3 alloy name).

NOTE The presence of silver in the solder reduces the dissolution effect on silver containing metallization on components and therefore can be used when required by the relevant component specification.

7.1.3 Lead-free solder alloy

The preferred alloy composition to be used should consist of either a mass fraction of 3,0 % Ag, 0,5 % Cu, 96,5 % Sn (Sn96,5Ag3Cu,5) or 0,7 % Cu, 99,3 % Sn (Sn99,3Cu,7). (Refer to IEC 61190-1-3 for the alloy name.)

NOTE Sn96,5Ag3Cu,5 is also known as SAC 305.

Other lead-free solder alloys may be used upon agreement between user and supplier.

7.1.4 Solder contamination control

The solder in solder baths used for solderability testing shall be chemically or spectrographically analyzed or replaced each 30 operating days. The levels of contamination and Sn content shall be within those shown in Table 2. The intervals between analyses may be lengthened if the test results indicate that the contamination limits are not being approached. The composition of the lead-free solder, including contamination levels, shall be maintained during testing with the silver and copper element levels adjusted for alloy requirements.

An operating day consists of any eight-hour period, or any portion thereof, during which the solder is liquefied and used. If contamination exceeds the limits specified in Table 2, then the solder shall be changed and the intervals between analysis shall be shortened. A sampling plan shall be developed, implemented, and documented. It shall also indicate the process control of the solder contamination.

Table 2 – Maximum limits of solder bath contaminants

Contaminant	Maximum mass fraction contaminant limit	
	SnPb alloys ^{a, b}	Lead-free alloys ^{c, d}
	%	%
Copper	0,300	1,100
Gold	0,200	0,200
Cadmium	0,005	0,005
Zinc	0,005	0,005
Aluminium	0,006	0,006
Antimony	0,500	0,200
Iron	0,020	0,020
Arsenic	0,030	0,030
Bismuth	0,250	0,250
Silver	0,100	4,000
Nickel	0,010	0,050
Lead	N/A	0,100
^a The tin content of the solder shall be maintained within $\pm 1,5$ % of the nominal alloy being used. Tin content shall be tested at the same frequency as testing for copper/gold contamination. The balance of the bath shall be lead and/or the items listed above. ^b The total of copper, gold, cadmium, zinc, and aluminium contaminants shall not exceed 0,4 %. Not applicable to lead-free alloys. ^c The tin content of the solder shall be maintained within ± 1 % of the nominal alloy being used. Tin content shall be tested at the same frequency as testing for copper/silver concentration. The balance of the bath shall be the items listed above. ^d Maximum contamination limits are applicable for Sn96,5Ag3Cu,5. Other lead-free solder alloy contamination limits may be used upon agreement between user and vendor.		

7.1.5 Solder mass for solder globule wetting balance method

For the solder globule wetting balance method, the solder shall be in the form of pellets or cut wire (here after referred to as "solder pellet") with a mass of 200 mg $\pm$ 10 mg for use on ~~a~~ the 4 mm diameter ~~pin~~ globule support block pin (here after referred to as "pin"), 100 mg $\pm$ 10 mg for use on ~~a~~ 3,2 mm diameter pin ~~support block~~, 25 mg $\pm$ 2,5 mg for use on ~~a~~ the 2 mm diameter pin ~~globule support block~~, and, 5 mg $\pm$ 0,5 mg for use on ~~a~~ the 1 mm ~~diameter globule support block~~ pin. Refer to Table 3.

Table 3 – ~~Globule and pellet sizes~~ Pin diameter and solder pellet mass

Pin diameter mm	~~Pellet mass~~ mg	~~Pellet mass tolerance~~ mg	Solder pellet mass mg
1	~~5~~	~~$\pm 0,5$~~	5 $\pm$ 0,5
2	~~25~~	~~$\pm 2,5$~~	25 $\pm$ 2,5
3,2	~~100~~	~~± 10~~	100 $\pm$ 10
4	~~200~~	~~± 10~~	200 $\pm$ 10

A new solder pellet shall be used for each test except in the case of a step and repeat technique. Separate dedicated globule support blocks should be used for tin-lead and lead-free alloys to avoid cross-contamination. Refer to ~~Annex C regarding dimple globule~~ C.5.1.1 c) regarding the concave aluminium body head.

7.2 Flux

7.2.1 Rosin based flux

The preferred fluxes for the test are rosin based as shown below. See Table 4 for the details.

- a) Non-activated
- b) Low activated
- c) High activated

Table 4 – Rosin based flux compositions

Constituent ^a	Composition by mass fraction %		
	Non-activated	Low activated	High activated
Colophony	25 ± 0,5	25 ± 0,5	25 ± 0,5
Diethylammonium hydrochloride (CAS No. 660-68-4)	None	0,15 ± 0,01	0,39 ± 0,01
2-propanol (Isopropyl alcohol) (CAS No. 67-63-0) or ethyl alcohol (CAS No. 64-17-5) as an alternative	75 ± 0,5	74,85 ± 0,5	74,61 ± 0,5
Mass of chlorine of solids ^b	0	0,2	0,5
^a See IEC 60068-2-20:2008, Annex B for specification.			
^b Expressed as free chlorine based on the colophony content.			

7.2.2 Flux maintenance

The flux to be used for testing should be taken from the supplied container and poured into a small cup (beaker). Flux applied for testing should be taken from this cup. After use the unused flux left in the cup should be discarded.

7.2.3 Test flux selection criteria

Refer to Clauses B.5 and B.8 for information regarding the adoption and use of these test fluxes.

8 Procedure

8.1 Test temperature

8.1.1 Solder alloy containing lead

Solder temperature prior to test and during test shall be 235 °C ± 3 °C.

8.1.2 Lead-free solder alloy

Unless otherwise specified in the relevant specification, the temperature of the solder prior to the test shall be 245 °C ± 3 °C for Sn96,5 Ag3 Cu,5 and 250 °C ± 3 °C for Sn99,3 Cu,7 alloys.

8.2 Test procedure

8.2.1 Applicable test procedure

Subclause 8.2.2 applies for leaded non-SMD.

Subclause 8.2.2 or 8.2.3 applies for non-leaded SMD or leaded SMD as applicable.

Subclause 8.2.4 applies for printed boards.

8.2.2 Solder bath wetting balance procedure

The specimen is mounted in a suitable holder to give the desired dipping angle and the termination(s) is/are centred above the solder bath. Preferred dipping angles are given in Table 5.

The temperature of the solder prior to the test shall be as described in 8.1.

Prior to testing, a continuous layer of the appropriate flux is applied to the portion of the component termination to be tested, using a cocktail stick, cotton bud or similar applicator, and excess flux droplets are removed by touching against absorbent paper. It is very important that excess flux is not allowed to enter the specimen holder or remain on the component. The presence of excess flux will cause explosive boiling as the flux solvent makes contact with the molten solder.

Immediately prior to testing, wipe the oxide from the solder bath surface with a non-wettable blade. If required, the apparatus suspension and chart recorder are adjusted to the zero position.

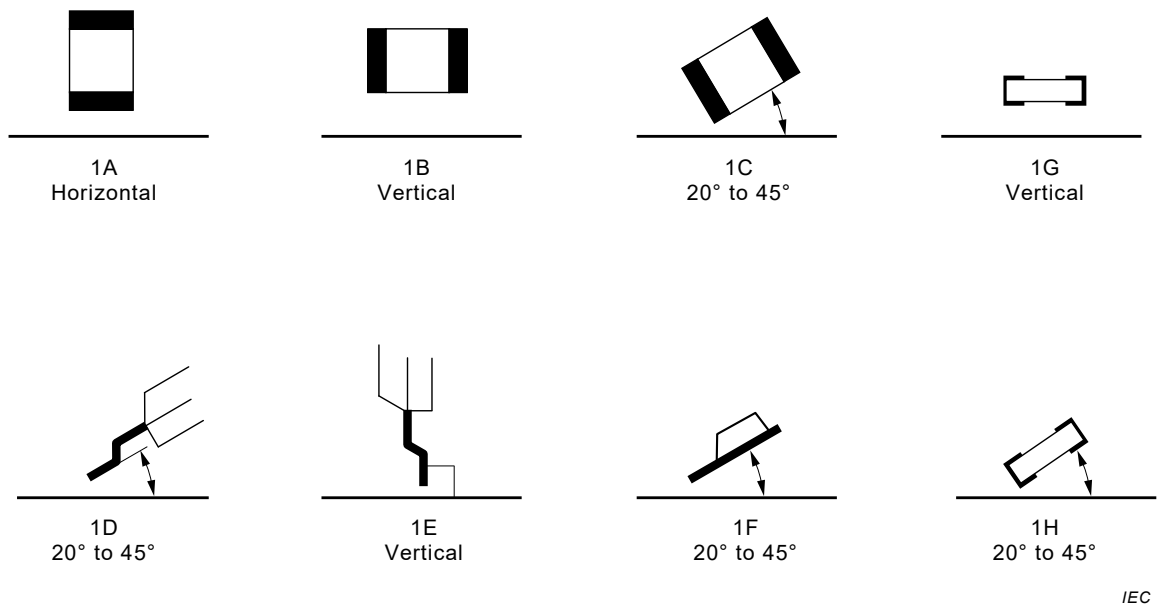
Leaded non-SMD component: Hang the specimen on the apparatus so that the lower edge of the component is $20\text{ mm} \pm 5\text{ mm}$ above the solder surface. The specimens are then brought into contact at a speed between 5 mm/s and 20 mm/s so that they are immersed to the required depth within $0,2\text{ s}$.

SMD components: It is important to ensure that the test specimen, at the start of the test, is positioned on the equipment at a distance not greater than $10\text{ mm} \pm 2\text{ mm}$ and to allow the specimen to preheat/dry for $30\text{ s} \pm 15\text{ s}$ prior to immersion into the solder globule. This period is required to remove the solvent from the flux prior to the test and to prevent explosive boiling when the specimen and solder come into contact. Loading and unloading of test specimens may, of course, be at a much greater distance, for example greater than 20 mm . The specimen and solder are brought into contact at a speed between 1 mm/s and 5 mm/s .

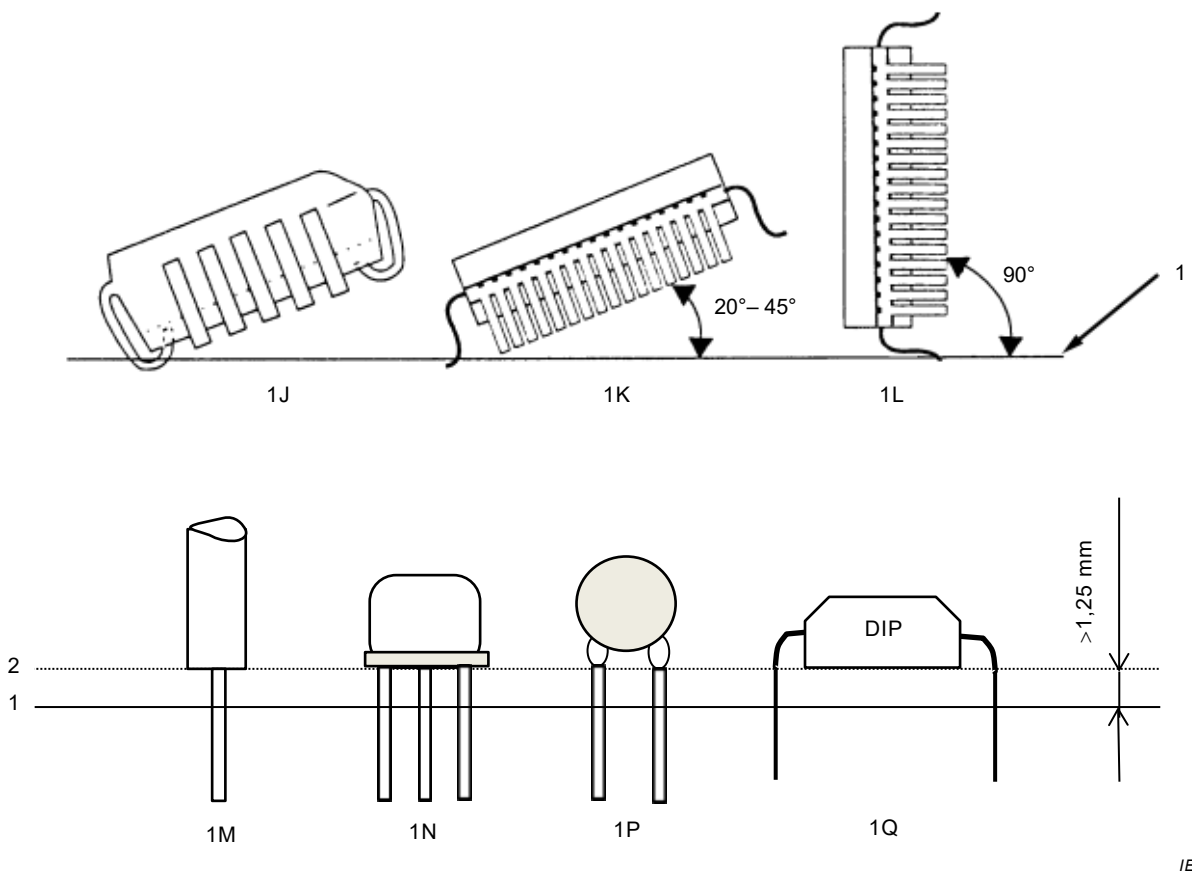
The recommended immersion depth into the solder of the surface to be tested shall be as specified in Table 5. See also Figure 3. Table 5 shows the solder dipping angle for SMD, leaded SMD components as well as leaded non-SMD components.

Table 5 – Recommended solder bath wetting balance test conditions

Component examples		Dipping angle ^a	Figure 3	Immersion depth mm
Type	Size code			
Leaded non-SMD	N/A	Vertical	1M, 1N, 1P, 1Q	2 to 4
Capacitors	1608M (0603) ^b 2012M (0805) ^b 3216M (1206) ^b 4532M (1812) ^b	Horizontal, vertical or 20° to 45°	1A, 1B, 1C	0,04 to 0,10
Resistors	1608M (0603) ^b 2012M (0805) ^b 3216M (1206) ^b	Horizontal, vertical or 20° to 45°	1A, 1B, 1C, 1G ^d , 1H ^d	
Leaded SMD	SOT 23 SOT 89 SOT 223 SOIC 16 ^c SOIC 28 ^c VSO 40 ^c QFP 48 ^c QFP 160 ^c PLCC 44 ^c PLCC 84 ^c	Vertical or 20° to 45°	1D, 1E, 1F 1J, 1K, 1L	
Cylindrical SMD	N/A	Horizontal, vertical or 20° to 45°	1A, 1B, 1C	
SOD 80	N/A	Vertical or 20° to 45°	1B, 1C	
Not recommended for sizes below 1608M (0603).				
The recommended dwell time is 5 s, except for SOT 89 and SOT 223 components, where 10 s is recommended.				
The recommended immersion speed for all components is between 1 mm/s and 5 mm/s, except for leaded non-SMD where between 5 mm/s and 20 mm/s is recommended.				
The immersion depths are recommended values. When appropriate, a higher immersion depth or longer dwell time can be chosen, for example in case of inadequate thermal heat transfer. See B.7.3.1 for precautions.				
^a Orientation of the specimen terminals or leads towards the solder surface.				
^b Size code in parentheses, dimensions are expressed in Imperial.				
^c These leads may be cut and tested individually, but care should be taken not to deform the part of the lead to be tested. This operation should be performed after ageing, if any ageing procedure is applied.				
^d 1G and 1H in Figure 3 a) are applicable to the components which do not have an electrode toward the solder surface when 1B is applied.				



a) – Examples of immersion A to H



Key

1 Molten solder surface

2 Seating plane

b) – Examples of immersion J to Q

Figure 3 – Immersion conditions for solder bath method

The solder and specimen are held in this position for not less than 5 s and then separated.

The withdrawal rate is not specified as the force curve is not analysed once the specimen starts to separate from the solder.

The time sequence of the test is shown in Table 6. To maintain repeatability, the test sequence time should be as short as possible.

Table 6 – Time sequence of the test (solder bath)

Procedure	Time s	Duration s
1) Fluxing	0	5
2) Hang the specimen on the apparatus	~15	10
3) Wipe the oxide from the solder surface	~20	5
4) Preheat	~30	30 ± 15
5) Start	~75	3 to 25
6) Solder immersion	100 max.	5

The vertical force acting on the specimen is recorded during the period of contact between the solder and the specimen. The force during withdrawal need not be recorded, as the withdrawal part of the curve is not analysed.

Once the specimen has cooled, the flux residues are washed from the specimen, using a neutral organic solvent. The specimen is visually examined using a magnification of 10×. Special attention should be paid to de-wetting, as de-wetting does not often occur until the specimen is withdrawn from the solder.

Note that de-wetting may be obscured by the presence of solder icicles frozen onto the termination as it is withdrawn from the solder.

8.2.3 Solder globule wetting balance procedure

Unless otherwise specified in Annex C for 0603M (0201) capacitors/resistors, the following procedure shall be applied.

Select the appropriate ~~globule block~~ pin diameter for the component to be tested. Recommended ~~globule support block pin sizes~~ pin diameters are given in Table 7.

Set the temperature of the solder as specified in 8.1. Note that the globule blocks should never be heated without solder covering the iron pin. Heating the uncovered pin could cause the iron to become oxidized and difficult to wet.

The specimen is mounted in the appropriate holder, to give the desired dipping angle, and the termination to be tested is centred above the solder globule. Recommended dipping angles and immersion depths for a typical range of components are given in Table 7 and Figure 4.

Prior to testing, a continuous layer of the appropriate flux is applied to the portion of the component termination to be tested, using a cocktail stick, cotton bud or similar applicator, and excess flux droplets are removed by touching against absorbent paper. It is very important that excess flux is not allowed to enter the specimen holder or remain on the component. The presence of excess flux will cause explosive boiling as the flux solvent makes contact with the molten solder.

Immediately before the test, the solder from the previous test should be removed, by wiping the globule block with a cotton bud, and replaced by a new pellet of the appropriate mass.

~~Sufficient activated rosin flux (0,5 % halide,~~ High-activated rosin base as specified in 7.2.4)

shall be applied to the solder globule. This maintains a clean surface for the duration of the test, and ensures that the iron pin is fully wetted and the solder formed into a regular hemispherical shape. If required the apparatus suspension and recording device are adjusted to the zero position.

Hang the specimen on the apparatus so that the lower edge of the component is $10 \text{ mm} \pm 2 \text{ mm}$ above the solder globule and allow the specimen to preheat/dry.

The specimen and solder are then brought into contact at a speed between 0,1 mm/s and 5 mm/s. The immersion depth of the surface to be tested into the solder shall be as specified in Table 7, which gives immersion depths for a typical range of components, and Figure 4.

Table 7 – Recommended solder globule wetting balance test conditions

Component examples		Dipping angle ^b	Figure 4	Immersion depth	Pin-size diameter	Globule Solder pellet mass	Remarks	
Type	Size code			mm	mm	mg		
Capacitors	0603M (0201) ^{a c}	Horizontal	2A	0,02 or 0,01	2 or 1	25 or 5	Refer to Annex C	
	1005M (0402) ^a	Horizontal or vertical	2A, 2B	0,10	2	25		
	1608M (0603) ^a							
	2012M (0805) ^a	Horizontal	2A		3,2 or 4	100 or 200		
	3216M (1206) ^a		4		200			
Resistors	0603M (0201) ^{a c}	Horizontal	2A		0,02 or 0,01	2 or 1	25 or 5	Refer to Annex C
	1005M (0402) ^a	Horizontal	2A	0,05	2	25		
		Vertical	2B	0,10				
	1608M (0603) ^a	Horizontal or vertical	2A, 2H ^d					3,2 or 4
	2012M (0805) ^a							
	3216M (1206) ^a			4		200		
Tantalum capacitors, LEDs	A ^e , B, C ,D	Vertical	2H ^d	0,10	4	200		
Leaded SMD ^f	SOT 23, 25, 26, 323, 343, 353, 363	20° to 45°	2D	0,10	2	25		
	SOT 89		2F	0,20	4	200	1 outer pin only	
	SOT 223, 523			0,25				
	Gull wing diode		2D	0,20			Remove sufficient leads to avoid bridging between tested leads	
	Any SOIC VSO QFP, SOP							
	PLCC, SOJ	Horizontal	2E	0,10				
QFN	N/A	Horizontal	2H ^d	0,10	2	25	Caution from bridging	
Cylindrical SMD	N/A	Horizontal or vertical	2A, 2B	0,25	4	200		
SOD 80	N/A	Vertical	2B	0,20	4	200		

Component examples		Dipping angle ^b	Figure 4	Immersion depth	Pin-size diameter	Globule Solder pellet mass	Remarks
Type	Size code			mm	mm	mg	
Any BGA, CSP or LGA ^g	N/A	Horizontal	2G	0,10	2	25	Only peripheral balls can be tested
BGA	ball pitch <1 mm	Horizontal	2G	0,05	1	5	Only peripheral balls can be tested
Not recommended for sizes below 0603M (0201). Bath method is preferred for capacitors 3216M (1206) size. The recommended dwell time is 5 s, except for SOT 89 and SOT 223 components where 10 s is recommended. For diagram 2B in Figure 4, a rightward offset may be used. The rightward offset distance from the crest of the solder globule shall be 0 % to 15 % of the pin diameter and shall avoid leftward offset.							
^a Size code in parentheses, dimensions are expressed in Imperial. ^b Orientation of the specimen terminals or leads towards the solder surface. ^c Details of the test conditions for 0603M (0201) capacitors/resistors are specified in Annex C. ^d Diagram 2H in Figure 4 is applicable to the components which do not have an electrode toward the solder surface when 2B is applied. ^e This test may only be applicable with certain test equipment. ^f These leads may be cut and tested individually, but care should be taken not to deform the part of the lead to be tested. This operation should be performed after ageing, if any ageing procedure is applied. ^g This test is recommended only for those balls and bumps that will not melt at the respective temperature and that are not designed to melt during reflow operation.							

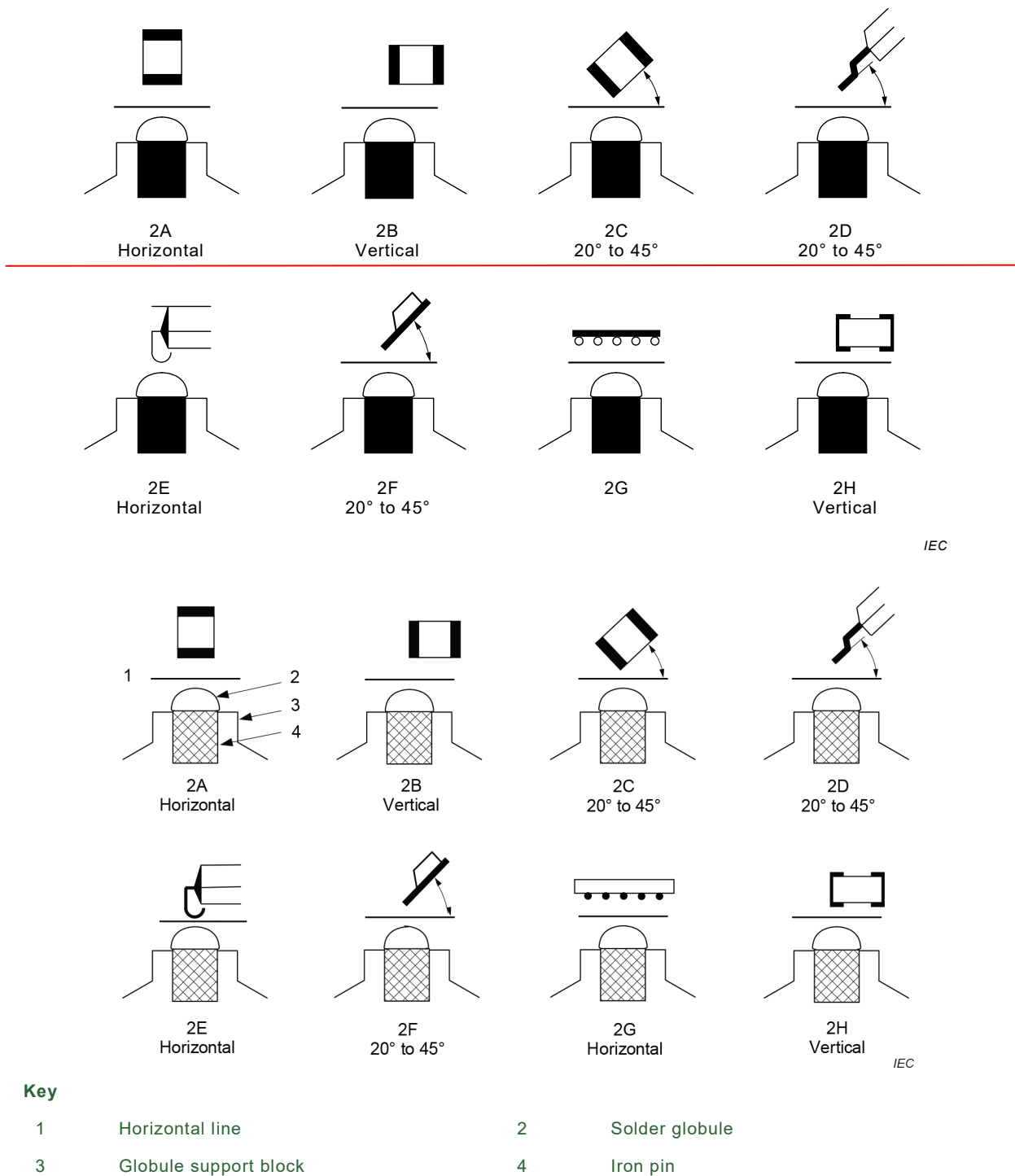


Figure 4 – Immersion conditions for solder globule method

The solder and specimen are held in this position for not less than 5 s and then separated.

The withdrawal rate is not specified as the force curve is not analysed once the specimen starts to separate from the solder.

The time sequence of the test is shown in Table 8. To maintain repeatability, the test sequence time should be as short as possible.

Table 8 – Time sequence of the test (solder globule)

Procedure	Time s	Duration s
1) Ensure that the globule pin surface is clean and locate new solder pellet	0	10
2) Hang the specimen on the apparatus	~15	5
3) Apply flux to solder globule	~30	–
4) Preheat	~40	30 ±15
5) Start	~85	3 to 25
6) Solder immersion	110 max.	5

The vertical force acting on the specimen is recorded during the period of contact between the specimen and solder. The force during withdrawal need not be recorded as the withdrawal part of the curve is not analysed.

The flux residues are washed from the specimen, once the specimen has cooled, using a neutral organic solvent. The specimen is visually examined using a magnification of 10×. Special attention should be paid to de-wetting, as de-wetting does not often occur until the specimen is withdrawn from the solder.

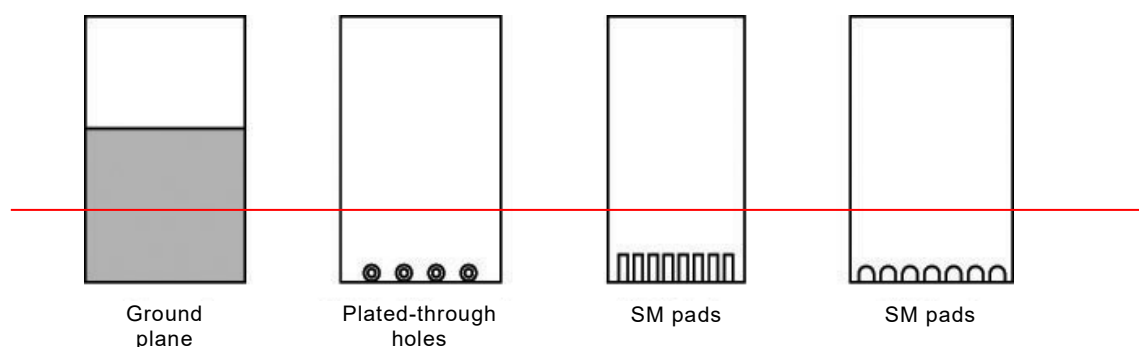
Note that de-wetting may be obscured by the presence of solder icicles frozen onto the termination as it is withdrawn from the solder.

8.2.4 Procedure for testing printed board specimens

8.2.4.1 Test specimen

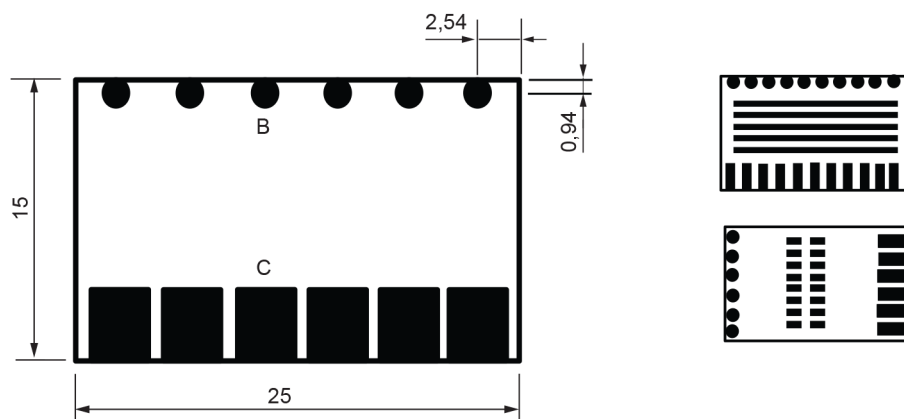
~~The test specimen shall either be a full board, a section of a board, or a suggested test specimen as illustrated in Figure 5.~~

The test specimen shall be a full board, a section of a board or the test specimen as specified in the relevant specification. If the relevant specification does not specify the test specimen, the test specimens shown in Figure 5 may be used.



IEC

Dimensions in millimetres



IEC

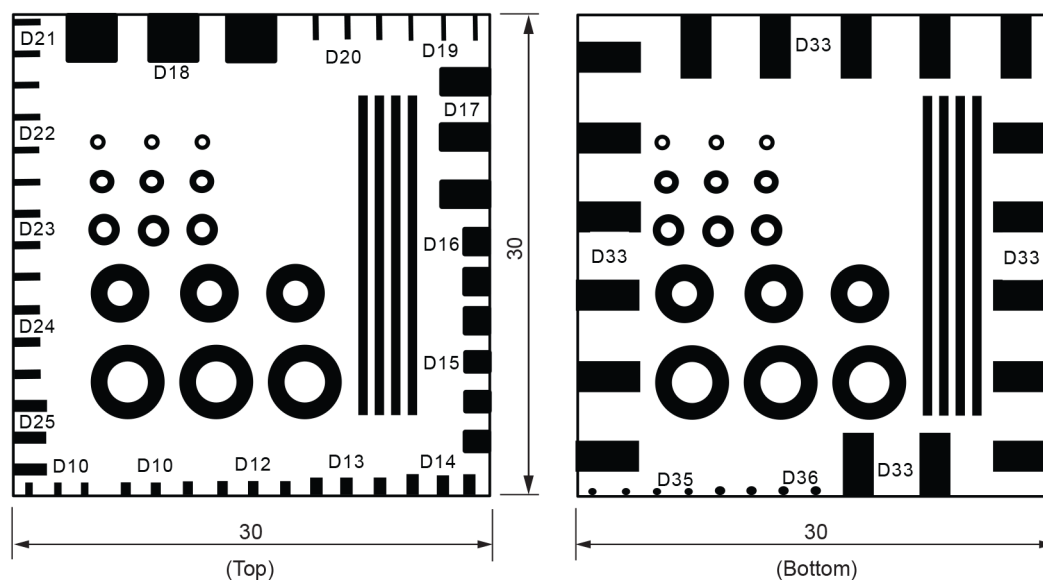
NOTE The figures on the right-hand side show the alternative configurations.

Symbol	Width	Length	Pad-to-pad pitch	Pad extension beyond the edge
B	1,9	round	4,0	—
C	3,18	4,52	4,0	0,51

[SOURCE: IPC 003c-4-2]

a) Test specimen for solder bath method

Dimensions in millimetres



IEC

Symbol	Width	Length
D10	0,698 5	0,899 2
D11	0,549 4	0,698 5
D12	0,800 1	1,000 8
D13	1,000 8	1,099 8
D14	0,899 2	1,399 5
D15	1,300 5	1,498 6
D16	1,600 2	1,798 3

Symbol	Width	Length
D17	1,798 3	3,200 4
D18	2,999 7	2,999 7
D19	0,170 2	1,600 2
D20	0,248 9	1,600 2
D21	0,299 7	1,600 2
D22	0,350 5	1,798 3
D23	0,399 8	1,798 3

Symbol	Width	Length
D24	0,500 4	1,798 3
D25	0,599 4	2,199 6
D33	1,899 9	3,799 8
D35	0,500 4	round
D36	0,599 4	round

[SOURCE: NPL Report MATCA(A)03, Figures 2 and 3 (TB26)]

b) Test specimen for solder globule method

**Figure 5 – Suggested wetting balance test specimens
and soldering immersion for printed boards**

8.2.4.2 Printed board test procedure

8.2.4.2.1 Procedure for solder bath method

The test specimens ~~are to~~ shall be dipped in the flux to the full depth to be soldered for 5 s to 10 s. The flux shall be maintained at the prescribed composition defined in 7.2.1. After withdrawal from the flux, the test specimen shall be allowed to drain vertically for a maximum of 60 s. Excess flux shall be removed by blotting the surface to be tested with a piece of absorbent, clean material. The solderability test shall then be performed in not less than 1 min, and not more than 5 min, after blotting.

Hang the specimen on ~~to~~ the apparatus so that its lower edge is $10\text{ mm} \pm 1\text{ mm}$ above the solder bath to preheat it for $20\text{ s} \pm 1\text{ s}$ ~~as shown in Figure 6~~. The test shall be started after clearing the surface oxide from the molten solder and waiting for a period of $5\text{ s} \pm 5\text{ s}$ for the bath surface to settle down.

The flux-covered surface shall be immersed only once in the molten solder to a depth of $0,20\text{ mm} \pm 0,1\text{ mm}$, and the angle of immersion shall be 20° to 40° , as shown in Figure 6. The angle of immersion shall be 20° to 40° . An angle of 90° may be used only upon agreement between user and supplier on immersion angle selection. The immersion speed shall be 1 mm/s to 5 mm/s and the dwell time shall be $5,0^{+0}_{-0,5}\text{ s}$. All test specimens shall have the flux removed using a suitable cleaning agent.

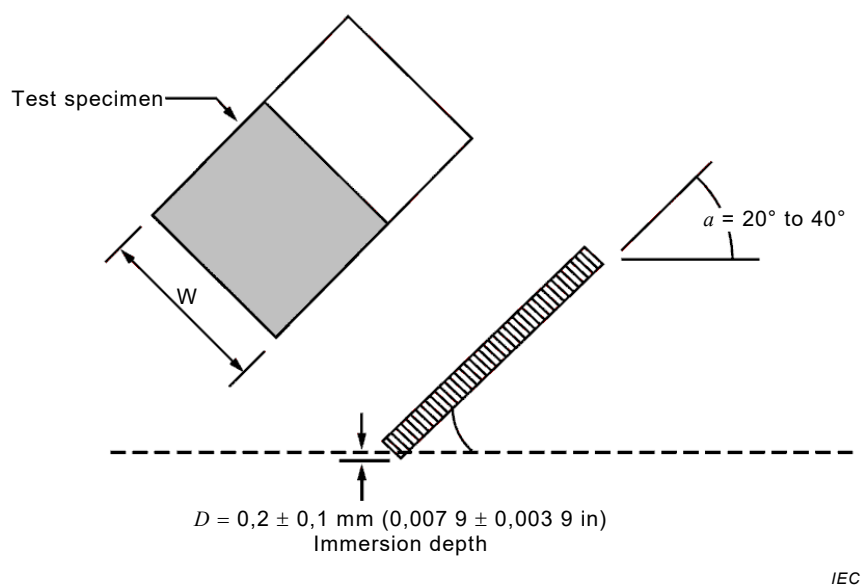


Figure 6 – Printed board immersion

The time sequence of the test is shown in Table 6. To maintain repeatability, the test sequence time should be as short as possible.

8.2.4.2.2 Procedure for solder globule method

As per 8.2.3 with the following details:

- a) pin diameter: 4 mm;
- b) solder pellet mass: 200 mg;
- c) flux type: high activated rosin-based flux as specified in 7.2.1;
- d) dipping angle: 45° ;
- e) immersion depth: 0,10 mm;

- f) immersion speed: 1 mm/s;
- g) dwell time: 10 s.

The time sequence of the test is shown in Table 8. The test sequence time should be the least possible whilst maintaining repeatability.

9 Presentation of results

9.1 Form of force versus time trace

The trace may be recorded in two forms, the only difference being the polarity of the force readings. In this document, forces acting upwards on the specimen (non-wetting) are shown as negative and forces acting downwards on the specimen (wetting) are shown as positive.

A typical wetting balance trace is shown in Figure 7.

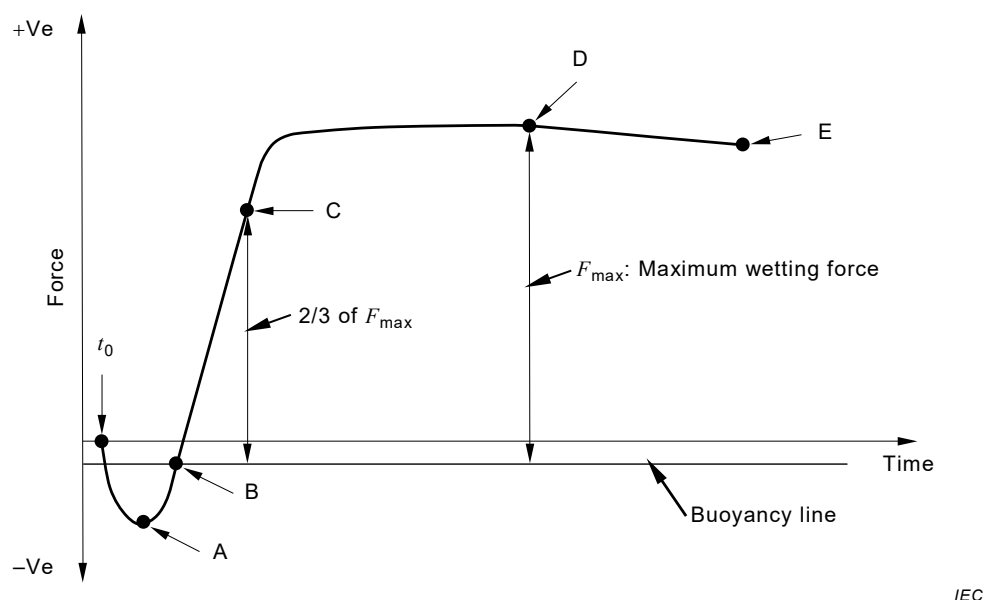


Figure 7 – Typical wetting balance trace

Time t_0 is the time at which the solder surface and the specimen first make contact, as indicated by a small downward movement of the trace from the zero line.

At point A the solder meniscus starts to rise up the specimen termination. This is normally characterized by a significant increase in the wetting force.

At point B the contact angle is 90° . The measured force is that due to the buoyancy of the component.

At point C the wetting force reaches $2/3$ of the maximum value of the resultant wetting force and the wetting force shall exceed a specified value within a specified time.

At point D the maximum value of the resultant wetting force is reached during the specified immersion period.

Point E is the force reading at the end of the specified test period.

Interpretation of the trace after E, during the withdrawal of the specimen, is not considered.

The wetting force in Figure 7 may be measured from the zero line, the buoyancy line, or the minimum forces at point A (the force excursion).

NOTE Certain components may wet so easily that there may be no downward movement of the trace from the zero line. This represents good solderability.

A pictorial understanding of the wetting curve steps 1 through 5 may be seen in B.7.3.5.

9.2 Test requirements

The requirements for the solderability of the components shall be expressed in terms of one or more of the following parameters:

- a) For the onset of wetting
A maximum value for the time interval (t_0 to B).
- b) For the progress of wetting
A maximum value of the time interval (t_0 to C).
- c) For the stability of wetting
A minimum value for the ratio: $\frac{\text{force at E}}{\text{force at D}}$

NOTE Examples of the criteria are described in B.7.4 and Annex D.

10 Information to be given in the relevant specification

The following items shall be specified in the relevant specification if applicable.

	Subclause
a) Whether the specimen is to be cleaned prior to testing	6.1
b) Whether accelerated ageing is to be carried out and, if so, by which method	6.2
c) Type of flux to be used	7.2
d) Composition of the solder	7.1
e) ~~Globule size~~ Pin diameter and solder pellet mass to be used	8.2.3
f) Test temperature, if other than specified	8.1
g) Portion of the specimen to be tested, if other component than indicated in Table 5 and Figure 3 or Table 7 and Figure 4	8.2.2, 8.2.3
h) Dipping position and angle if other component than indicated in Table 5 and Figure 3 or Table 7 and Figure 4	8.2.2, 8.2.3
i) Immersion depth, if other component than indicated in Table 5 and Figure 3 or Table 7 and Figure 4	8.2.2, 8.2.3
j) Duration of the test, if other than 5 s	8.2.2, 8.2.3
k) Acceptance value for the onset and progress of wetting	9.2
l) Areas to be visually examined for wetting and de-wetting	8.2.2, 8.2.3

Annex A (normative)

Equipment specification

A.1 Characteristics of the apparatus

For the purpose of this document the complete apparatus, including the computer system or the chart recorder, is to be considered as a single piece of equipment having the following characteristics.

- a) The response time of the recording device shall be such that return to centre zero on removal of the maximum load shall be accomplished within 0,3 s, with an overshoot not exceeding 1 % of the corresponding maximum reading.
- b) The instrument may have a number of sensitivity settings. On the most sensitive setting, it shall be capable of resolving a force of less than 0,02 mN
 - 0,02 mN for SMD and printed board, or
 - 0,04 mN for leaded non-SMD components.
- c) The deflection of the recording device shall be directly proportional to the force applied over the entire range to an accuracy better than ± 5 % of the full-scale deflection.
- d) Electrical and mechanical noise on the force trace shall not exceed
 - 10 % of the signal level, on the most sensitive range for SMD and printed board, or
 - the equivalent 0,04 mN for leaded non-SMD components.
- e) The stiffness of the spring system of a mechanical balance shall be such that a load of 10 mN causes a vertical displacement of the specimen suspension which does not exceed 0,1 mm.
- f) If a chart recorder is used, the chart speed shall be not less than 10 mm/s.
- g) The speed of immersion and withdrawal shall be between
 - 0,1 mm/s and 5 mm/s for SMD,
 - 5 mm/s to 20 mm/s for leaded non-SMD components, or
 - 1 mm/s and 5 mm/s for printed board.
- h) The immersion depth shall be adjustable to an accuracy of
 - $\pm 0,01$ mm for SMD,
 - $\pm 0,2$ mm for leaded non-SMD components, or
 - $\pm 0,1$ mm for printed board.
- i) The solder temperature shall be maintained at the specified temperature in 8.1, but should be adjustable between 200 °C and 260 °C.
- j) The time at maximum immersion shall be adjustable from 0 s to 10 s.

A.2 Solder bath

The bath shall be of sufficient thermal mass to enable the test temperature to be maintained to the required precision. No part of the specimen shall be less than 15 mm from the wall, so that the wetting forces are not affected by the curvature of the solder surface at the edges of the bath. The depth of the bath shall not be less than 15 mm.

A.3 Globule support blocks

A.3.1 The body shall be made from a non-heat-treatable aluminium bar having a minimum yield stress of 170 N/mm² and the following chemical composition:

Magnesium	1,7 % to 2,8 %
Copper	0,1 % maximum
Silicon	0,6 % maximum
Iron	0,5 % maximum
Manganese	0,5 % maximum
Chromium	0,25 % maximum
Zinc	0,2 % maximum
Titanium or other grain refining elements	0,15 % maximum
Aluminium	the remainder

See ISO 6362.

A.3.2 The 1 mm, 2 mm, 3,2 mm and 4 mm diameter iron pins shall be made of pure iron, or low carbon steel having the following composition:

Carbon	0,05 % maximum
Oxygen	0,02 % maximum
Nitrogen	0,02 % maximum
Other impurities	15×10^{-6}
Iron	the remainder

See ISO 683.

A.3.3 The mild steel pin shall be heat shrunk into a reamed hole in the aluminium body.

A.3.4 The aluminium body shall be heated by an electrical heater and the temperature controlled by any means which will ensure a temperature within ± 3 °C of the specified temperature in 8.1.

A.3.5 The temperature shall be measured by inserting a suitable probe, such as a thermocouple, thermistor or platinum resistance wire, into a hole bored into the iron pin.

A.3.6 The top surface of the iron pin shall be tinned. After completion of the test, the globule support block shall be allowed to cool with a solder globule in position, to prevent oxidation of the iron pin and subsequent dewetting.

A.3.7 The relative positions of the specimen and the solder globule shall be adjustable in both horizontal axes.

A.3.8 When testing micro-components such as 0603M(0201) and employing the conditions of Annex C, the globule support block shall have a dimpled top surface as shown in Figure C.1.

Annex B (informative)

Use of the wetting balance for SMD solderability testing

B.1 Definition of the measure of solderability

The wetting balance method permits the measurement of the vertical force acting on a specimen as a function of time, when the specimen is immersed in a bath of molten solder or a molten solder globule. The solderability of the specimen is deduced from these observations as the time to reach a given degree of wetting or as the degree of wetting reached within a given time.

In general the construction of surface mounted devices does not allow the full meniscus rise to develop, where the contact angle reduces to zero, and so the observed wetting force cannot be compared to the theoretical wetting force.

A specification for solderability may require that several points on the force-time curve conform to particular values. Annex B suggests points and values that may be used.

The test equipment shall conform to certain requirements if reproducible and quantitative results are to be obtained. The requirements and methods of verifying that they are complied with are also included in Annex B.

The choice of method will depend upon the type of component to be tested and the level of information required from the test. The relevant component specification will indicate which method is preferred.

Important information:

To ensure consistent results between the user and vendor, only the flux, alloy, and test temperatures stipulated should be used.

In case different fluxes, solder alloys and temperatures are used, the criteria for evaluation of the test results shall be set appropriately and agreed upon.

B.2 Gauge R&R – Test protocol for wetting balance gauge repeatability and reproducibility using copper foil coupons

B.2.1 Test coupon

All coupons for these tests shall be prepared individually just prior to testing. Do not clean the samples in batches.

A copper foil of 35 μm nominal thickness (“1 oz” copper) shall be used for the test.

The copper foil shall have no surface treatment and is expected to have an oxidized appearance upon receipt from the supplier. Do not use the copper foil if it is bright and shiny. This is indicative of surface anti-tarnish treatments being used. Surface treatments/preservatives can interfere with the ability to make a consistent “known good coupon” necessary for this test.

The copper foil coupons shall be die cut to ensure repeatability of the samples being tested and shall be of the following width dimensions:

a 2 mm b 5 mm c 10 mm.

Create a file for each foil width and for each individual person involved that is performing the GR&R.

B.2.2 Test parameters

The solder temperature shall be as recommended for the alloy and the specification being used, i.e., for SnPb solder alloy it shall be 245 °C. For lead-free solder alloy it shall be 255 °C, regardless of the specification.

- Immersion depth shall be 0,4 mm.
- Immersion speed shall be 2 mm/s.
- Dwell time in the solder shall be 10 s.
- Immersion angle shall be 90° incident to the solder.

No preheat shall be used.

B.2.3 Known good coupon

Sample preparation for the “known good coupon” shall be as follows:

- a) use tweezers to immerse a foil sample into a beaker of acetone and gently agitate for 20 s;
- b) remove the sample and blot both sides dry with lint free tissue or other suitable lab tissue;
- c) again using tweezers, immerse the above sample into a 20 % v/v Nitric acid solution and gently agitate for 20 s;
- d) immerse the sample immediately into DI water and gently agitate for 20 s;
- e) blot the sample dry as in step b) above;
- f) dip the sample into the “standard activated flux” normally used for solderability testing for 5 s;
- g) holding the samples vertically, blot to remove excess flux;
- h) place the sample into the tool holder;
- i) run the test.

Repeat ten times for each foil width and each test person. It is recommended that three people should be used for the GR&R study.

For ease of data manipulation it is recommended to convert the wetting forces obtained into mN/mm of wettable length. For the 10 mm coupon for example, the wettable length is 2 times 10 mm plus 2 times 0,035 mm for a total length of 20,07 mm.

For the “standard activated” flux of nominal 0,2 % activation, the wetting force used for the calculations shall be 0,31 mN/mm for SnPb solder alloy and 0,36 mN/mm for lead free solder alloy. If a more active flux is being used, a large sample shall be run to obtain the mean value and this used for the calculations.

Calculate the standard deviation for each of the foil widths and the people running the test.

Multiply the standard deviation value by 6 (this represents the ± 3 standard deviations of a normal distribution).

Divide this number by the wetting force and multiply by 100 to obtain a percentage value.

Tabulate the three values per person.

For an acceptable GR&R, the values obtained should be below 10 %.

There should be excellent R&R results with the 10 mm coupon the first time this protocol is performed with an increasing spread from test person to test person when using the smaller coupons. The test may have to be repeated or the individuals allowed some “practice time” prior to running the full GR&R.

In addition to testing the individual, this protocol also tests the machine and will show linearity and any bias if it exists. Because the wetting forces have been set to mN/mm, the readings for each coupon width should be the same. If they are clearly different but the standard deviations produced by the individual test people are below 10 %, then there is a problem with the wetting balance and the manufacturer should be contacted.

B.3 Solder-globule pellet mass and pin-size diameter

The solder globule wetting balance method is standardized using 4-sizes pin diameters (4 mm, 3,2 mm, 2 mm and 1 mm-diameter) for the iron insert in the aluminium block, and-5 4 corresponding solder pellet-sizes masses (200 mg, 100 mg, 25 mg and 5 mg-and-2,5 mg).

In general, the smaller solder pellet-sizes masses give improved discrimination with the smaller SMDs and facilitate testing of individual leads on fine-pitch devices, such as QFPs (quad flat packs) and BGAs (ball grid arrays). The 200 mg-globule pellet mass is required for all larger SMD and multi-leaded SMD, where the 25 mg solder-globule pellet mass has insufficient volume to completely solder the terminations. The 100 mg-globule solder pellet mass provides a larger wetting force than the 200 mg-globule solder pellet mass and larger thermal inertia than the 25 mg-globule solder pellet mass. With the advent of even smaller SMDs, such as 0603M (0201), a smaller pin-size, 1 mm diameter of 1 mm, and-globule-size solder pellet mass 5 mg or 2,5 mg, may be required to match these finer SMD sizes.

A list of recommended pin-sizes diameters and-globule-mass solder pellet masses is given in Table 7 and Annex C.

The solder globule used with the solder globule wetting balance method is a limited source of heat and so will be able to discriminate between different thermal requirements on a component. An extreme example of this is the SOT 89 and SOT 223 devices where the centre lead has a much higher thermal requirement than the two outer leads.

B.4 Specimen orientation and immersion depth

B.4.1 General

Surface mounted devices generally have short terminations and so it is advisable to use shallow immersion depths to leave the largest area available above the solder, to develop the largest possible wetting force. The buoyancy forces under these conditions will be relatively small.

However, this should be balanced against the thermal needs of the component. The use of very shallow immersion depths may give poor or unpredictable heat transfer into the component, giving variable times before the onset of wetting. Too high immersion depths will give poor wetting force readings. Table 5 and Figure 3 give a list of recommended immersion depths for a range of common components, for the solder bath method, and Table 7, Figure 4 and Annex C give the recommended immersion depths for the solder globule wetting balance method.

As a general guide, where a termination can be presented as a straight vertical face, this will provide the best results. However, it is also necessary to ensure that solder can flow along the face that will eventually be soldered to the printed board. The solder shall also be brought

into contact with the solderable coating, avoiding contact with unsolderable material, including exposed cut ends. The immersion angle shall also allow sufficient thermal contact to provide adequate heat transfer into the component.

These requirements will have a different consequence for dipping orientation and dipping depth, for different components.

B.4.2 Resistors and capacitors

Large capacitors can be immersed into the solder with the terminations horizontal, but resistors will generally give better results when one termination is tested vertically, or at an angle between 20° and 45°. Small size capacitors, 1608M (0603) and smaller, may also give better results when dipped with the terminations vertical, or at an angle between 20° and 45°. The smaller pellet size is preferred for 1005M (0402) and 1608M (0603) sizes. It is also recommended that these components be immersed generally to one side of the globule as shown in diagram 2B of Table 7 and Figure 4.

NOTE Components names in parentheses, dimensions are expressed in Imperial.

B.4.3 Small-leaded components

SOT 89, SOT 23 and SOT 223 devices may be dipped at 45°, as the ends of the terminations are cut in the manufacturing process exposing the bare metal which is generally nonsolderable by conventional test fluxes. By using a dipping angle of 45° the molten solder is brought into contact with the solderable part of the termination, allowing the solder to advance over the termination before the contact angle decreases to zero.

These components are heated to such an extent during the test that adjacent leads are reflowed. Thus, only one lead may be tested on a device. In general, greater sensitivity is obtained by using the smaller solder globule to test these components.

B.4.4 Multi-leaded devices

A complete row of leads on a multi-leaded device can be tested using the solder bath. Greater discrimination may be obtained by removing alternate leads or alternate pairs of leads to reduce the effect of capillary action between the leads, or individual leads may be carefully cut from the component.

The solder globule wetting balance method can be used to test individual leads on a multileaded device, but may also require leads to be removed to prevent solder making contact with two leads or with the solder residue remaining on the previously tested lead.

A complete row of leads on a multi-leaded device may be tested using a single solder globule, but components with a high thermal mass may show variable times for the onset of wetting, because of the differing preheat times and temperatures.

SOIC, VSO and QFP devices may require dipping at an angle of 45°, since these devices have cut ends which are non-wettable by conventional test fluxes. Only by using a shallow dipping angle can the solderable surface be brought into contact with the solder. This problem is common to a large number of devices.

PLCC devices should be dipped with the body horizontal and require alternate leads to be removed, to avoid the solder spike remaining on the previously tested lead making contact with the solder globule.

BGA devices should be dipped with the body horizontal. With this arrangement it is possible to test the outer row of solder balls. Alternate solder balls shall be tested to avoid pickup of solder and flux residue from adjacent solder balls.

B.5 Test flux

For the solder bath test specified in 8.2.2, flux is only applied to the component termination and either of the fluxes in 7.2 may be specified.

For the solder globule wetting balance method, flux is applied to both the component termination and the solder globule. Either of the fluxes specified in 7.2 may be used on the component termination. It has been found that the pure rosin flux, specified in 7.2, is not capable of maintaining a clean solder surface for the duration of the test. Where a different flux is used on the component termination, it has been found that a little intermixing occurs.

If the user wishes to employ a test flux that is more representative of modern flux formulations (e.g. no clean fluxes), then the following formulations shown in Table B.1 and Table B.2, can be considered that have similar discriminating powers to the rosin test fluxes.

Table B.1 – Carboxylic acid based flux (water solution)

Constituent	Composition by mass fraction %
De-ionised water	90,1
Glycol ester (CAS No. 34590-94-8)	5,0
Adipic acid	1,6
Succinic acid	1,6
Glutaric acid	1,6
Alcohol ethoxylate surfactant (CAS No. 68131-39-5)	0,1

Table B.2 – Carboxylic acid based flux (alcohol solution)

Constituent	Composition by mass fraction %
Propan-2-ol	94,0
Adipic acid	1,5
Succinic acid	1,5
Glutaric acid	1,5
Colophony	1,5

B.6 Test temperature

B.6.1 Solder alloy containing lead

The test temperature of $235\text{ °C} \pm 3\text{ °C}$ is chosen to be consistent with existing IEC standards.

If a further enhancement of the discrimination is required, then $215\text{ °C} \pm 3\text{ °C}$ may be used. If required by the relevant specification, other test temperatures may be specified.

The preferred test temperatures are the following:

$235\text{ °C} \pm 3\text{ °C}$

$215\text{ °C} \pm 3\text{ °C}$

$245\text{ °C} \pm 3\text{ °C}$

Certain coatings, for example organic brightened tin or gold, show a significant change in their rate of solution in solder with 60 % tin and 40 % lead between 235 °C and 245 °C . In such a situation, the relevant specification should state whether a solder bath temperature of 245 °C may be used for testing.

B.6.2 Solder alloy without lead

The test temperature of $245\text{ °C} \pm 3\text{ °C}$ was determined from the IPC (Association Connecting Electronics Industries) round robin test program that substantiated the use of Sn96,5Ag3Cu,5. The JNC (Japanese National Committee for IEC TC91), however, also includes the use of Sn99,3Cu,7 for which the test temperature shall be $250\text{ °C} \pm 3\text{ °C}$.

B.7 Characteristics of the test apparatus

B.7.1 Recording device

B.7.1.1 Zero setting

During the test cycle, the force acting on the specimen reverses direction as non-wetting changes to a wetted condition. When testing surface mounted devices the buoyancy force will generally be negligible, as the immersion depths are very small. The wetting force-time trace will generally show a small non-wetting force and a relatively larger wetting force. The recording device should be adjusted to a level consistent with keeping the whole curve on the chart or display.

B.7.1.2 Response time (see Clause A.1 a))

The response time of the recording device shall be small enough to ensure that it reproduces accurately the rapid changes in force that take place, particularly at the commencement of wetting. Although in theory this should be infinitely small, in practice a maximum response time of 0,3 s has proved satisfactory.

Thus, a chart recorder can be used as a recording device, although it is more common to digitize the force-time signal and analyse it by computer.

The following procedure may be used to test the response time of the recording device and the instrument zero stability if this information is not available. It requires the use of a known mass (which should be sufficient to give a full-scale deflection of the recording device from the mid-point zero) and a specimen holder suitable for holding the mass:

- with the specimen holder in place, set the recorder to zero;
- start the recording device at its maximum speed;

- place the mass on the specimen holder;
- after 3 s remove the mass, leaving the recorder running;
- after 3 s replace the mass on the specimen holder;
- repeat the operation at least five times, before stopping the recorder.

The force-time trace will give the sensitivity and response time of the apparatus, for the given settings and the zero stability.

B.7.1.3 Sensitivity settings (see Clause A.1 b))

The provision of a range of sensitivities allows specimens of different sizes to be tested. In general large ranges will have lower resolutions than small ranges. For surface mounted devices it is desirable that a full-scale deflection of 2 mN or less is attainable.

B.7.1.4 Chart speed (see Clause A.1 f))

If a chart recorder is used to record the force-time trace it is recommended that a minimum chart speed of 10 mm/s be used, to allow sufficient discrimination of the important points on the force-time curve.

B.7.2 Balance system

B.7.2.1 Stiffness of the spring (see Clause A.1 e)

The balance system measures the displacement of (typically) a spring assembly induced by the applied force acting on the specimen. Such a displacement produces a change in the depth to which the specimen is immersed in the solder and, in consequence, a change in the buoyancy force. It is therefore necessary that the spring system be sufficiently stiff so that its deflection and the consequent change in buoyancy during the course of the test is negligible by comparison with other forces being measured.

When testing surface mounted devices where the immersion depth is generally very small this is not a serious problem, but it will become a more critical factor if the balance is used to test larger specimens with larger buoyancy forces.

B.7.2.2 Noise level (see Clause A.1 ed))

The level of electrical and mechanical noise in the balance and amplifier system shall not exceed 10 % of the signal level on the most sensitive range.

B.7.3 Lifting mechanism and controls

B.7.3.1 Depth of immersion (see Clause A.1 h)

The depth to which the specimen is immersed in the molten solder (which shall be specified) has to fulfil the following conditions:

- a) in the wetting process the solder traverses the region of interest. On formed leads it will be necessary to select the correct immersion angle to ensure this occurs;
- b) the immersion depth should be sufficiently small to leave the majority of the termination free above the solder surface;
- c) the immersion depth should be sufficient to provide adequate thermal heat transfer into the termination;
- d) the depth of immersion shall be repeatable to within 0,01 mm to obtain repeatable results or 10 % in the worst case.

NOTE The deeper the immersion depth, the more the buoyancy offsets the zero force level from the centre zero and the less termination there is available for the solder to traverse.

The deeper the immersion depth, the greater the interface available for heat transfer from the solder to the specimen, hence the less the wetting process is delayed by thermal transfer effects.

B.7.3.2 Speed of immersion (see Clause A.1 g)

Solderability tests on surface mounted devices use very small immersion depths and hence only require slow dipping speeds. In most cases slow speeds enable greater immersion depth accuracy to be obtained. An immersion speed between 0,1 mm/s and 5 mm/s should ensure that most specimens are fully immersed before soldering commences.

B.7.3.3 Duration of immersion (see Clause A.1 j)

For surface mounted devices a dwell time of 5 s will usually be sufficient for small specimens.

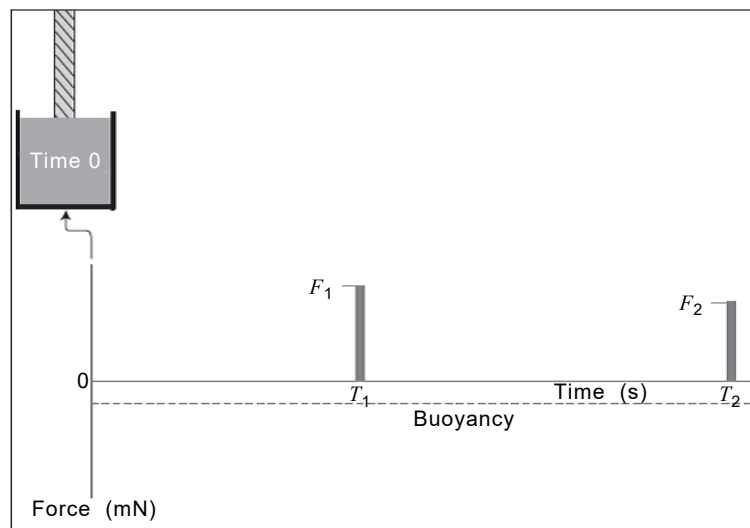
A dwell time of 10 s may be necessary for large components and specimens with particularly high thermal capacities.

B.7.3.4 Solder globule x/y position

In order to use the solder globule wetting balance method, the solder globule is required to be positioned accurately beneath the component termination. This is generally achieved by a mechanical table capable of being positioned in the x (left to right) and y (back and forward) directions. An accuracy of $\pm 0,05$ mm is recommended, especially if successive component leads are to be tested on a multi-leaded device, where any positional error will be compounded as the globule advances along the device.

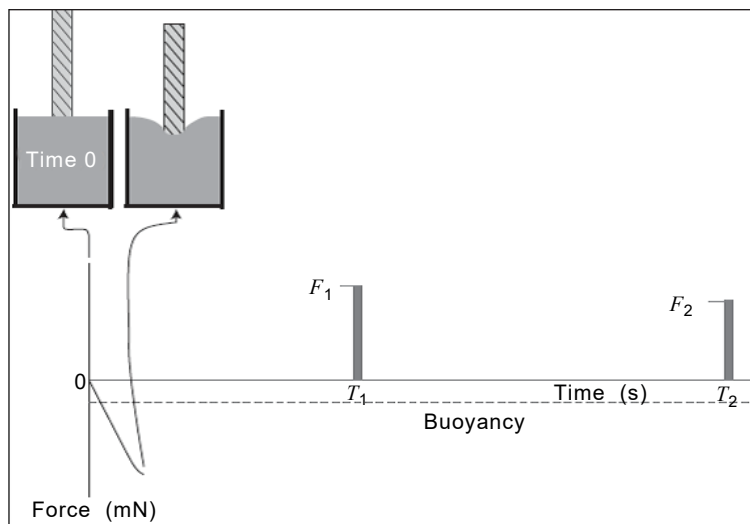
B.7.3.5 Understanding wetting curves

Figure B.1 shows steps 1 to 5 of the wetting curves.



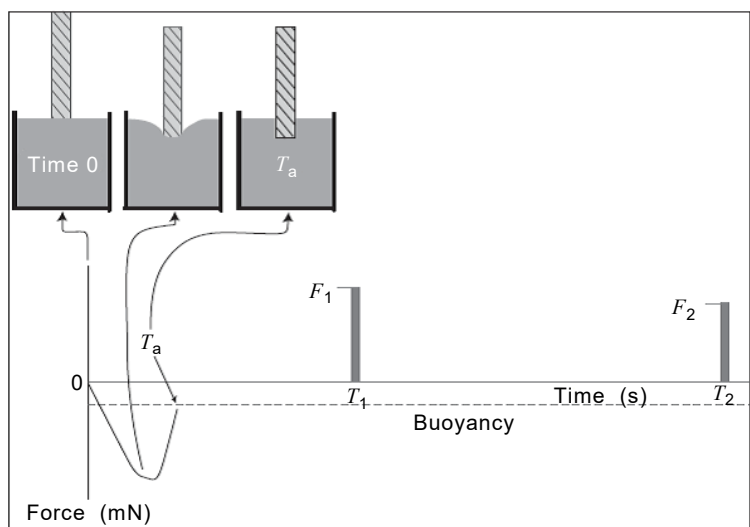
IEC

a) – Step 1



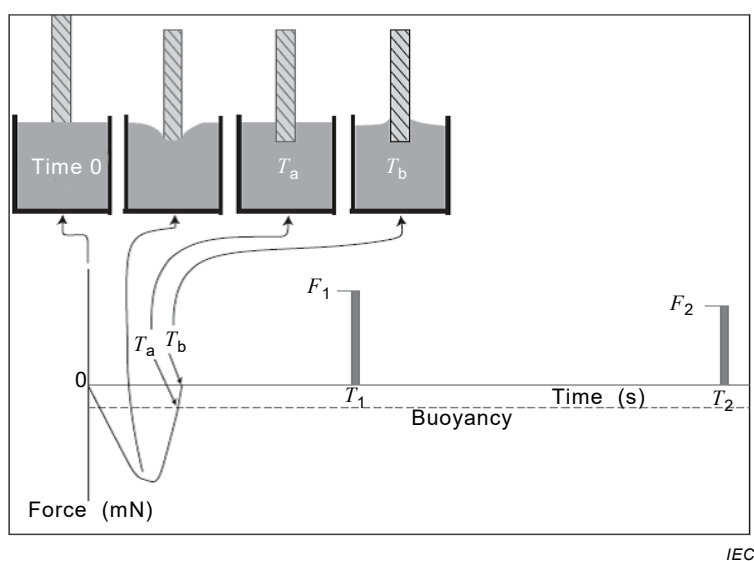
IEC

b) – Step 2

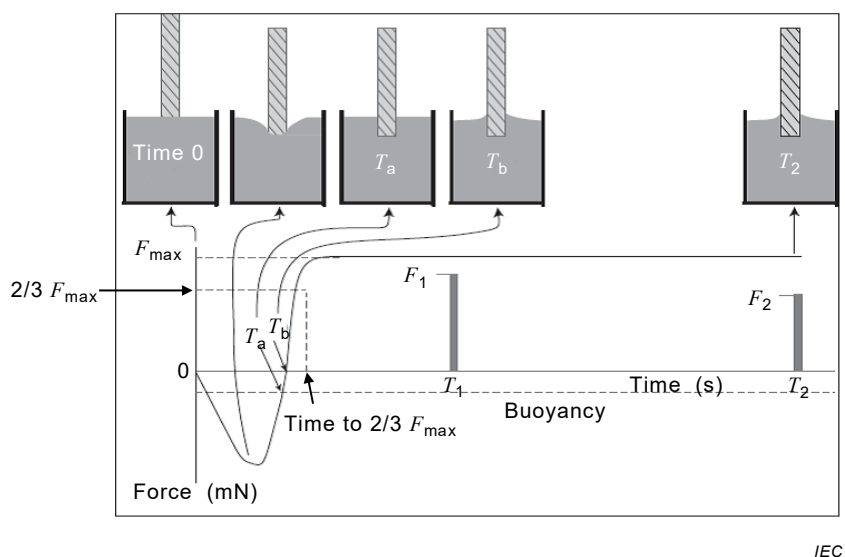


IEC

c) – Step 3



d) – Step 4



e) – Step 5

Figure B.1 – Understanding wetting curves

The net of the parameters measured from the progression of the five steps encountered during the wetting balance testing, as highlighted above, is shown in Figure B.2.

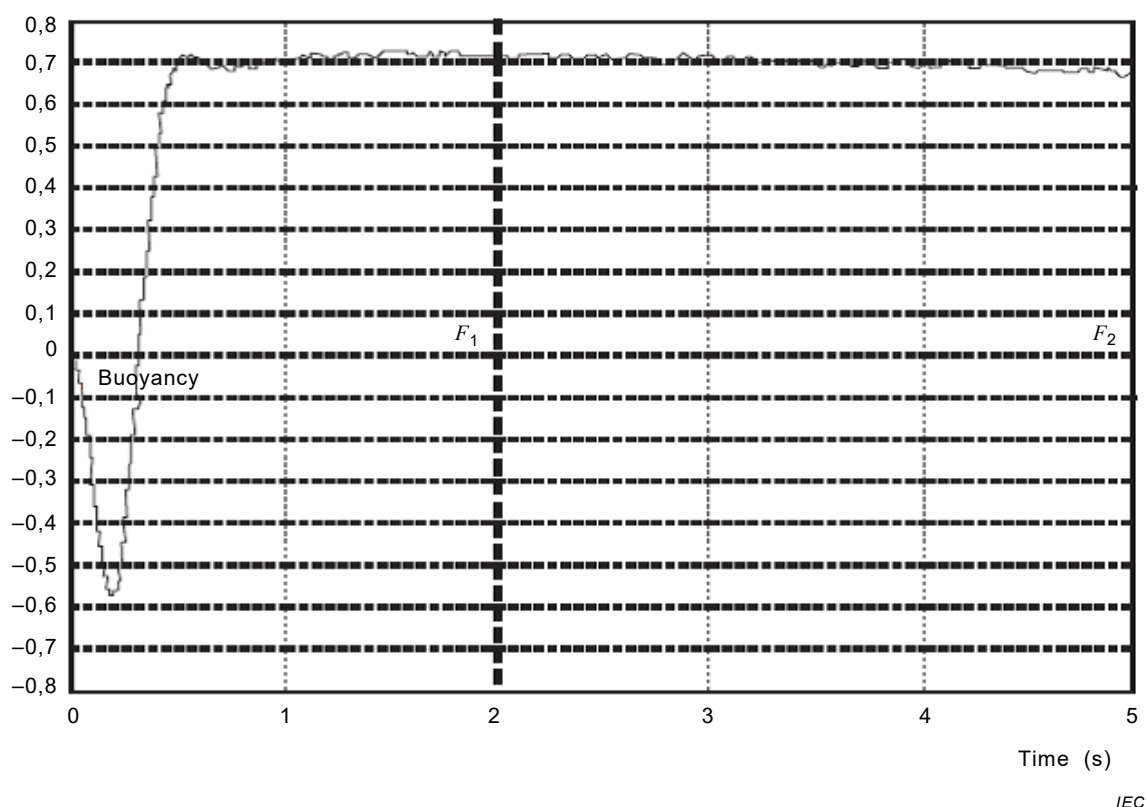


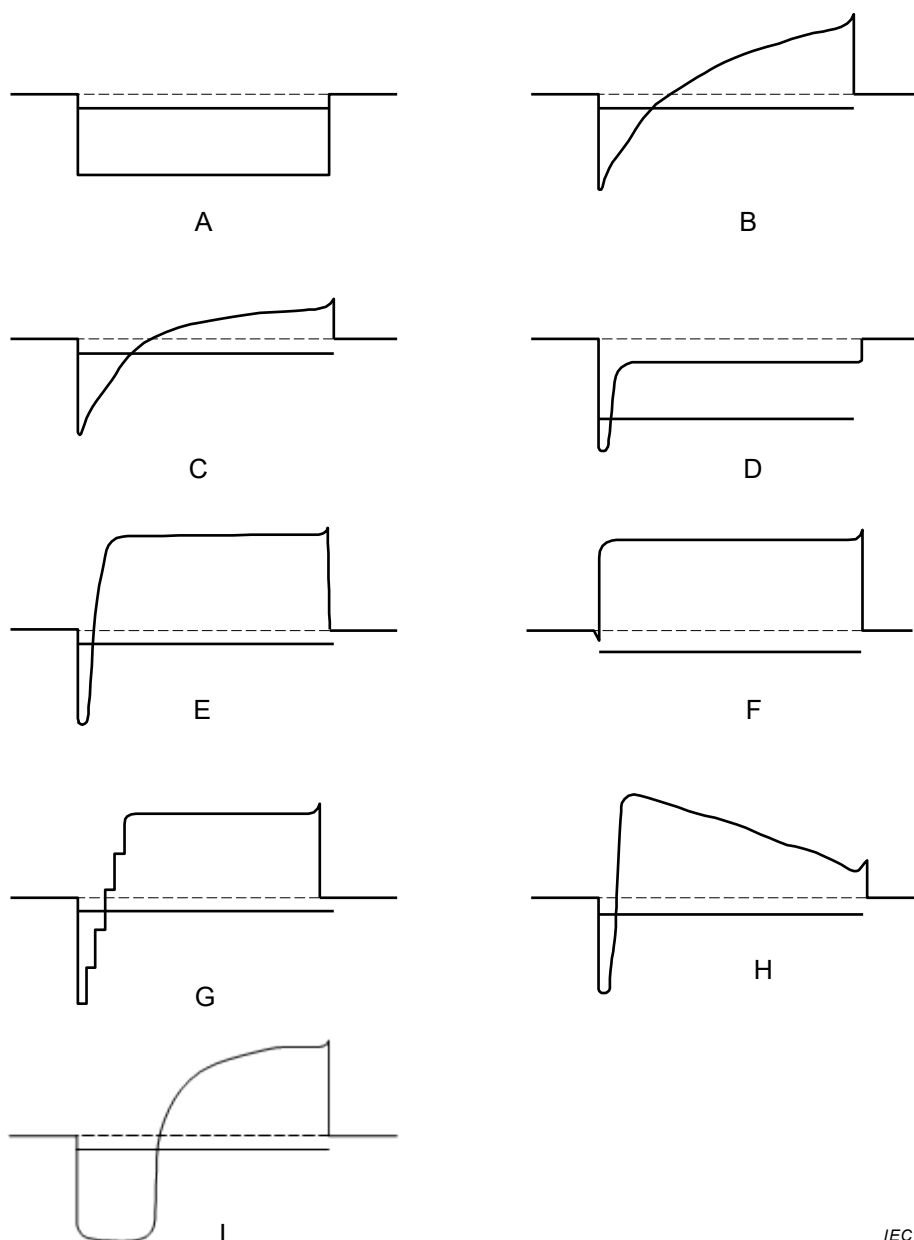
Figure B.2 – Typical wetting curve

B.7.3.6 Some representative force-time curves

In the examples shown in Figure B.3, the part of the curve representing forces acting upward on the specimen, i.e. non-wetting state, is shown as negative, the curve representing forces acting downward, i.e. wetting, is shown as positive.

The dotted line represents the condition at the start of the test cycle, having cancelled the weight of the specimen. The full horizontal line shows the buoyancy offset, where the wetting force is zero.

The buoyancy of the specimen can be calculated as the product of immersed volume and the density of the molten solder which it displaces. At the specified test temperature of 235 °C the rounded-off value of 8 g/cm³ should be used for the density of molten solder with 60 % tin and 40 % lead. For SnAgCu and SnCu solder alloys, the density of the molten solder rounded-off value of 7,1 g/cm³ should be used.



IEC

Key

A	Non wetting	B	Slow wetting
C	Poor wetting	D	Buoyant specimen
E	Good wetting	F	Very fast wetting
G	Fast wetting limited by thermal demand	H	Unstable wetting
I	Retarded wetting		

Figure B.3 – Representative force-time curves

B.7.4 Parameters to be measured from the force-time trace

B.7.4.1 Choice of test criteria

Since one of the advantages of this test method is that the whole of the wetting process is examined, it may be appropriate to use more than one of the parameters listed in 9.2 of this document when deciding the test requirements to be met.

B.7.4.2 Time for the onset of wetting

At point B (see Figure 7), the wetting process has advanced from a non-wetting state to the point where the solder meniscus is about to start to rise up the termination. The time interval between A and t_0 is thus the time for the onset of wetting, and will be influenced by the flux and the thermal characteristics of the specimen.

B.7.4.3 Progress of wetting

The measured force at a given time, or the time to reach a given force, should meet the specified requirement. It is recommended that a maximum time of 2 s is used or that the force reaches the required value within 2 s.

The required force may be determined by the method prescribed in B.7.5 or the values may be used as part of a statistical process control regime.

B.7.4.4 Stability of wetting

After the maximum force value D is attained, the meniscus may remain steady and the force value show no change. However, this stability may be disturbed by reactions between the specimen and the solder leading to dissolution of the specimen surface by the solder or the formation of a layer of reaction product at the interface. In addition, residual flux may evaporate, be decomposed or migrate over the molten solder surface. The solder coating of a dip tinned component may also melt above the advancing solder meniscus. All these effects may lead to a lowering of the measured force such that the value at the end of the test period E is less than the value recorded at D. Such instability is undesirable and an indication of possible problems with the component termination.

For test periods of 5 s to 10 s it is recommended that the ratio

$$\frac{\text{Force at E}}{\text{Force at D}}$$

exceed 0,8.

B.7.5 Reference wetting force

If the height of termination available on surface mounted devices is not sufficient to allow the full meniscus rise to develop, then a contact angle of zero is not attainable. This means that it is not possible to use the mathematical procedure in Annex E to calculate the theoretical maximum force.

To obtain a practical reference force against which to compare experimental results the following procedure shall be carried out, for each component to be tested.

Five samples are taken from the specimens to be analysed and tested using liquid flux to ISO 9454-1:1990, class 2.2.2.A. This is a highly activated organic flux, which will produce a reference best-case result on the component. The maximum force obtained on each of the five specimens is recorded and the mean calculated, to give a reference wetting force.

A percentage of this force may be used to set a required limit for the components to be tested and this should be stated in the relevant component specification. It is recommended that this force be specified at 2 s, but other times may be specified.

The samples should be examined visually to ensure that they are fully wetted and that there are no defects in the wetting of the terminations.

The results obtained from this method may also be used as part of a statistical process control regime to produce control charts for the components.

B.7.6 Equipment location

The equipment shall be located in a vibration and draft free environment, on a sturdy workbench. The addition of further equipment shall not affect the instrument balance performance and the level of measured noise, for example fume extraction equipment.

B.7.7 Globule pins

The globule pins are made of iron so, to avoid oxidation, it is essential to ensure that the globule pins are always tinned (covered with solder).

B.7.8 Globule modules

To avoid potential cross-contamination between tin lead and lead-free alloys, it is recommended that separate globule modules be employed that carry suitable markings to differentiate between those used for tin lead and those used for lead-free alloys.

B.8 Test flux – IPC-J-STD-002/J-STD-003 activated solderability test flux rationale committee letter

B.8.1 General

NOTE Copied, with permission, from IPC, with minor editorial amendments for consistency with this IEC International Standard.

The current IPC J-STD-002/J-STD-003 specification includes a departure in the test flux methodology used in past solderability testing

Constituent	Composition mass fraction	
	Flux #1 %	Flux #2 %
Colophony	25 ± 0,5	25 ± 0,5
Diethylammonium hydrochloride (CAS 660-68-4)	0,15 ± 0,01	0,39 ± 0,01
Isopropyl alcohol (IPA) (CAS 67-63-0)	Balance	Balance
Mass of chlorine as % of solids	0,2	0,5

The J-STD-002/J-STD-003 committees understood that any proposed change to the use of ROL0 (formerly designated type R) would be heavily scrutinized and would require test data. J-STD-002/J-STD-003 has spent significant resources working this flux change issue, discussing the chemistry details and conducting multi-company design of experiment investigations. The J-STD-002 committee chairmen, Dave Hillman [Rockwell Collins], Doug Romm [Texas Instruments], Mark Kwoka [Intersil], Jack McCullen [Intel], feel that the committee has compiled a significant data set and held through topic discussions supporting the proposed flux mat material change. The four rationales for proposing/supporting the flux change are summarized below:

B.8.2 Proactive solderability testing approach to the implementation of non-tin finishes

A number of industry studies (1996 NEMI Surface Finishes Task Group Report, 1997 NCMS Lead-Free Solder Project, 2000 National Physical Laboratory CMMT (A) 284 Report) have shown an incompatibility of "R type" flux with non-tin surface finishes such as palladium, organic solderability preservatives (OSPs), and immersion gold. The introduction of these various metallic surface finishes on components and printed boards is no longer the exception.

but has/is quickly becoming the norm. The use of an “R type” flux containing only naturally occurring activators has resulted in producing “false negative” solderability test results which impact both the component/printed board fabricator and the assembler negatively in terms of cost and schedule.

B.8.3 Reduced solderability test variability

The J-STD-002/J-STD-003 solderability committees enlisted the assistance of Dr. Carol Handwerker and the resources of the National Institute of Standards & Technology (NIST) to investigate/compare a standard activated flux composition versus the “R type” flux composition. A detailed statistical analysis by Bill Russell, Raytheon Systems, and NIST statisticians revealed the use of a standard activated flux composition greatly reduced the amount of solderability test variation. One of the major goals of the JSTD-002/003 solderability committees is to develop test methods and standards that promote consistency across the industry.

The two major historical rationales for using an “R type” flux are: 1) colophony or rosin contains only naturally occurring flux activator constituents and thus is not subjected to the problems/complications of chemistry formulas by the flux supplier; 2) it was an accepted industry-acknowledged fact that if a component or printed board surface was found to have acceptable solderability test results using “R type” flux then the more active flux formulations used in the assembly process would produce acceptable solder process results. This solderability assessment safety margin was a self imposed, industry consensus decision. The J-STD-002/J-STD-003 committees understood the historical relevance behind the decision to use “R type” flux and had an equally strong desire to maintain a solderability assessment safety cushion. However, committees fielded a number of industry inputs to reassess the solderability flux composition based on the technology improvements in surface finishes, improvements in the flux chemistry formulations from flux suppliers, and the desire to not have excessive safety margin which would impact cost and schedule in a non-value added manner. The committees conducted a number of tests (Wenger, Kwoka, ACI) demonstrating, using a specific standard level of activation on real world, industry supplied component and printed board cases, that the occurrence of a “false acceptable” solderability test result was extremely low. There was no case that exhibited a “pass ROL1 test – fail ROL0 test – Fail during board assembly” sequence. In fact the use of both ROL1 and ROL0 are more likely to create a “false reject” dip and look solderability test result when compared to board level soldering performance.

B.8.4 Standardization of solderability test flux composition on a global scale

A second major goal of the J-STD-002/J-STD-003 solderability committees is to develop test methods and standards which promote global standardization for the electronics industry. The standard activated flux composition selected and tested by the committees has been utilized in the International Electrotechnical Commission IEC 60068-2-20 soldering specification. The IEC specification is successfully utilized for solderability testing. Having compatibility of flux composition requirements between the J-STD-002/J-STD-003 specification and the IEC specifications is a win-win situation for electronics assemblers and component/printed board fabricators.

Annex C (normative)

Test methods for SMD components sizes 0603M (0201) or smaller

C.1 General

Annex C specifies two test methods for ultra-miniature sized SMD components such as 0603M (0201) or smaller by using the solder globule wetting balance method.

Annex C provides the standard procedures for both lead and lead-free solder alloys.

Method 1: This information was provided by the Japanese National Committee and is based upon lead-free alloys.

Method 2: This information was provided by the UK National Committee and is based upon tin-lead alloys.

C.2 General description of the test method

See Clause 4.

C.3 Preconditioning

C.3.1 Preparation of the specimens

See 6.1.

C.3.2 Ageing

As specified in 6.2 with the following exception:

Recommended ageing conditions are:

a) Ageing A: 155 °C for 4 h (test Bb in IEC 60068-2-2).

NOTE The specimen can be put into the oven at room temperature.

b) Ageing B: 120°C, 85 % RH for 4 h (test Cx in IEC 60068-2-66).

C.4 Materials

C.4.1 Solder

C.4.1.1 Solder material

As specified in 7.1.3.

C.4.1.2 Solder mass for solder globule wetting balance method

As specified in 7.1.5 with the following details:

Method 1: The solder shall be in the form of pellets or cut wire with a mass of 25 mg $\pm$ 2,5 mg.

Method 2: The solder shall be in the form of pellets or cut wire with a mass of 5 mg $\pm$ 0,5 mg.

C.4.2 Flux

As specified in 7.2.1 with the following details:

A non-activated flux shall be used for the specimen. A low-activated flux shall be used to form the solder globule.

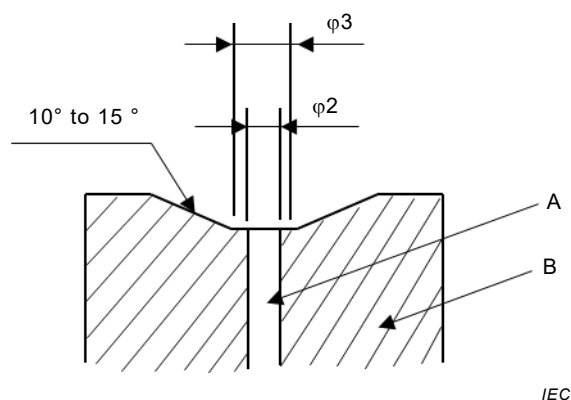
C.5 Method 1

C.5.1 Description of the test apparatus

C.5.1.1 Test apparatus

As specified in Clauses 5, A.1 and A.3 with the following exceptions:

- a) speed of immersion: $0,1 \text{ mm/s} \pm 0,01 \text{ mm/s}$;
- b) immersion depth: $0,02 \text{ mm}$;
- c) concave aluminium body head as shown in Figure C.1;
- d) diameter of the iron pin: 2 mm .



Key

A Iron pin

B Aluminium body

Figure C.1 – Cross-section of aluminium body

C.5.1.2 Observation equipment

The magnifier or video camera should be used to observe the specimen dipping angle and specimen alignment to the solder globule.

The magnifier or zoom camera to confirm the immersion attitude and alignment of the solder globule to the specimen shall be capable of detecting the position of a specimen and solder globule.

For example, the dimensions of the camera zoom view should be able to extend laterally 10 mm or less.

C.5.2 Procedures

C.5.2.1 Test temperature

As in 8.1.2.

C.5.2.2 Test preparation

The iron pin diameter shall be 2 mm as in C.5.1.1 d).

Set the temperature of the solder as specified in C.5.2.1. Note that the globule blocks should never be heated without solder covering the iron pin. Heating the uncovered pin could cause the iron to become oxidized and difficult to wet.

C.5.2.3 Flux application to the specimen and specimen holding

- a) Prior to testing, the specimen is mounted in the appropriate holder, to give the desired dipping angle (horizontal), and a continuous layer of the non-activated flux as in C.4.2 is applied to the portion of the component termination to be tested. The examples of flux application method are described below.
 - The specimen in the holder is immersed into flux.
 - Apply flux using a cocktail stick, cotton bud or similar applicator to the specimen in the holder.
- b) Excess flux droplets shall be removed by touching against absorbent paper. It is very important that excess flux is not allowed to enter the specimen holder or remain on the component. The presence of excess flux will cause explosive boiling as the flux solvent makes contact with the molten solder.
- c) After application of the flux, hang the specimen on the apparatus so that the termination of the specimen to be tested shall be centred above the solder globule from the previous test.

See Figure C.2.

The specimen dipping angle and specimen alignment to the solder globule should be ensured by observation using a magnifier or video camera.

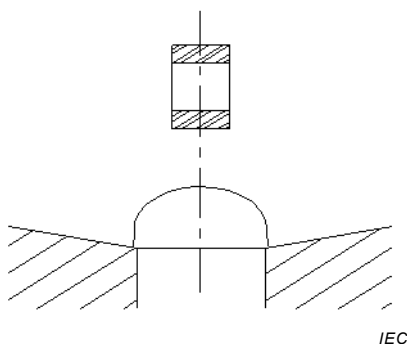


Figure C.2 – Dipping position and relative position

C.5.2.4 Solder globule preparation

Immediately before the test, the solder from the previous test should be removed, by wiping the globule block with a cotton bud, and replaced with a new solder as specified in C.4.1.1.

10 $\mu\text{L} \pm 1 \mu\text{L}$ of the activated flux as specified in C.4.1.2 shall be applied to the new solder using for example a micro-pipette. This procedure is to ensure the cleanness of the solder globule surface during the test period, and that the iron pin is completely wetted by solder and forms a hemispherical shape. If required, the apparatus suspension and the recording device are adjusted to the zero position.

C.5.2.5 Test and record

Test and record shall be done in the following sequence.

- a) Lower the specimen on the apparatus so that the lower edge of the component is 1 mm to 1,5 mm above the solder globule and allow the specimen to preheat/dry.
- b) The specimen and solder are brought into contact under the following conditions:
 - the immersion speed shall be 0,1 mm/s $\pm$ 0,01 mm/s;
 - the recommended immersion depth of the surface to be tested into the solder shall be 0,02 mm.
- c) The solder and specimen are held in this position for 5 s or more, then separated.
- d) The vertical force acting on the specimen is recorded during the period of contact between the specimen and solder. The force during withdrawal need not be recorded as the withdrawal part of the curve is not analysed.

NOTE The withdrawal rate is not specified as the force curve is not analysed once the specimen starts to separate from the solder.

C.5.2.6 Time sequence of the test

The time sequence of the test is shown in

Table C.1 and Figure C.3. To maintain repeatability, the test sequence time should be as short as possible..

Table C.1 – Time sequence of the test procedure

Step	Process	Accumulated process time ^a s	Reference
1)	Apply flux to the specimen	0	C.5.2.3 a)
2)	Remove excess flux from the specimen	~5	C.5.2.3 b)
3)	Hang the specimen on the apparatus	~15	C.5.2.3 c)
4)	Align specimen to the solder globule	~40	C.5.2.3 c)
5)	Wipe the remaining solder from the globule block	~50	C.5.2.4
6)	Supply new solder	~65	C.5.2.4
7)	Apply flux to the solder	~80	C.5.2.4
8)	Lower the specimen position above the solder globule	~90	C.5.2.5 a)
9)	Immersion to the solder	~110	C.5.2.5 b)
^a The accumulated process time starts from application of flux to the specimen.			