INTERNATIONAL STANDARD

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Second edition
2006-04

Environmental testing –

Part 2-54:
Tests – Test Ta: Solderability testing of electronic components by the wetting balance method

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ENVIRONMENTAL TESTING –

Part 2-54: Tests – Test Ta: Solderability testing of electronic components by the wetting balance method

FOREWORD

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International Standard IEC 60068-2-54 has been prepared by IEC technical committee 91: Electronics assembly technology.

This second edition cancels and replaces the first edition, published in 1985 and constitutes a technical revision.

The major technical changes with regard to the previous edition concern:

– the addition of lead free solder alloy (see Clause 7, Materials);
– reversal of force-time curves to align with IEC 60068-2-69 (see Figure 2 and Figure B.1);
– modification to the test requirement for progress of wetting (see Clause 9).

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

FDIS	Report on voting
91/576/FDIS	91/587/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.

IEC 60068 consists of the following parts, under the general title *Environmental testing:*

Part 1: General and guidance

Part 2: Tests

Part 3: Supporting documentation and guidance

Part 4: Information for specification writers - Test summaries

Part 5: Guide to drafting of test methods

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- withdrawn,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 2-54: Tests – Test Ta: Solderability testing of electronic components by the wetting balance method

1 Scope

This part of IEC 60068 outlines Test Ta, solder bath wetting balance method applicable for any shape of component terminations to determine the solderability. It is especially suitable for reference testing and for components that cannot be quantitatively tested by other methods. For surface mounting devices (SMD), IEC 60068-2-69 should be applied if it is suitable.

This standard provides the standard procedures for solder alloys containing lead (Pb) and for lead-free solder alloys.

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 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering*

IEC 61190-1-3, *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*

3 Terms and definitions

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

4 General description of the test

The specimen is suspended from a sensitive balance (typically a spring system) and immersed edgewise to a set depth in a bath of molten solder at a controlled temperature. The resultant of the vertical forces of buoyancy and surface tension acting upon the immersed specimen is detected by a transducer and converted into a signal which is continuously recorded as a function of time on a high-speed chart recorder. The trace may be compared with that derived from a perfectly wetted specimen of the same nature and dimensions.

Two modes of testing exist:

– The stationary mode, intended to study the solderability of a particular place on the specimen. It is this mode which is standardized in this standard.

– The scanning mode, intended to study the homogeneity of the solderability of an extended region of the surface of the specimen. The standardization of this mode is still under consideration.

5 Description of the test apparatus

5.1 Test system

A diagram of an arrangement suitable for the test is shown in Figure 1.

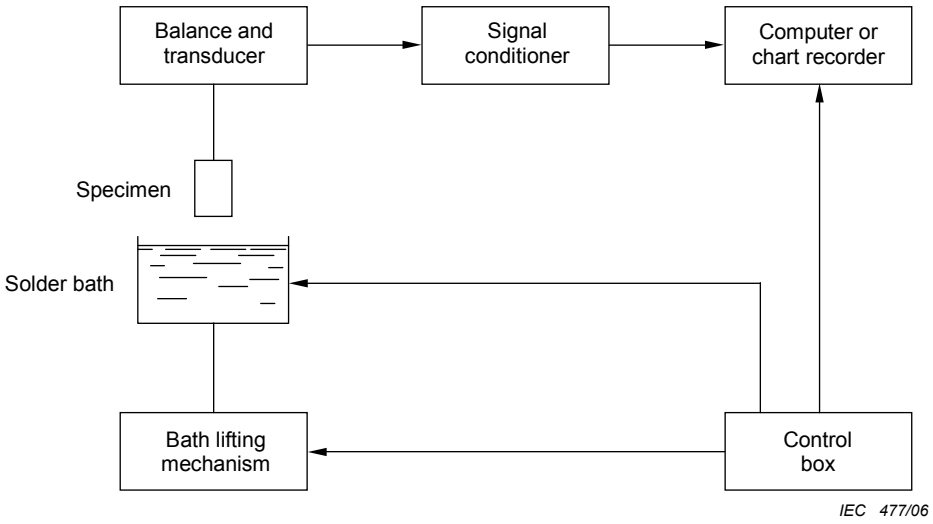

Figure 1 – Test arrangement

Any other system capable of measuring the vertical forces acting on the specimen is admissible, provided that the system has the characteristics given in Annex A.

5.2 Solder bath

The solder bath dimensions shall comply with the requirements of Clause A.7. The material of the solder bath container shall be resistant to the relevant liquid solder alloy.

6 Preconditioning

6.1 Preparation of specimens

The specimen shall be tested in the “as-received“ condition unless otherwise specified by the relevant specification. Care should be taken that no contamination, by contact with the fingers or by other means, occurs.

The specimen may be cleaned by immersion in a neutral organic solvent at room temperature, but only if required by the relevant specification; no other cleaning is permitted.

6.2 Ageing

When accelerated ageing is prescribed by the relevant specification, one of the methods of 4.5 of IEC 60068-2-20 shall be used.

7 Materials

7.1 Solder

7.1.1 General

Solder composition shall be specified in the relevant specification.

7.1.2 Solder alloy containing lead

The solder composition shall be either 60 % by mass (wt %) Sn(tin) and 40 wt % Pb(lead) according to Appendix B of IEC 60068-2-20 (Sn60Pb40A, according to IEC 61190-1-3) or 63 wt % Sn (tin) and 37 wt % Pb(lead) (Sn63Pb37A, according to IEC 61190-1-3).

7.1.3 Lead-free solder alloy

Unless otherwise specified in the relevant specification, the solder composition shall be either 3,0 wt % Ag(silver), 0,5 wt % Cu(copper) and the remainder of Sn(tin), Sn96,5Ag3,0Cu0,5, or 0,7 wt % Cu(copper) and the remainder of Sn(tin), Sn99,3Cu0,7, is preferred.

NOTE 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 Sn96,5Ag3,0Cu0,5. The solder alloys consist of 0,45 wt % to 0,9 wt % Cu and the remainder of Sn may be used instead of Sn99,3Cu0,7.

7.2 Flux

The flux to be used shall be either rosin based non-activated or rosin based activated as follows:

a) rosin based non-activated: consist of 25 wt % of colophony in 75 wt % of 2-propanol (isopropanol) or of ethyl alcohol (as specified in Appendix C of IEC 60068-2-20).
b) rosin based activated flux: the activated flux which is above flux with the addition of diethylammonium chloride (analytical reagent grade), up to an amount of 0,2 % or 0,5 % chloride (expressed as free chlorine based on the colophony content).

Information about the used flux type shall be given in the relevant specification.

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, solder temperature prior to test and during test shall be 245 °C ± 3 °C for Sn96,5Ag3,0Cu0,5 alloy and 250 °C ± 3 °C for Sn99,3Cu0,7 alloy respectively.

8.2 Fluxing

After mounting the specimen in a suitable holder, the portion of the surface specified shall be immersed in flux at room temperature. Excess flux is immediately drained off by standing the specimen vertically on clean filter paper for 1 s to 5 s.

8.3 Flux drying

The temperature of the solder prior to test shall be as specified in 8.1. The specimen is then suspended vertically with lower edge 20 mm ± 5 mm above the bath for 30 s ± 15 s to allow most of the flux solvent to evaporate, before initiating the test. During this drying period the suspension and the chart recorder trace shall be adjusted to the desired zero position, and immediately before starting the test, the surface of the solder bath is scraped with a blade of suitable material to remove oxides.

8.4 Test

The specimen is then immersed at a speed of 5 mm/s ± 1 mm/s to 20 mm/s ± 1 mm/s to the specified depth in the molten solder and held in this position for a specified time and then withdrawn. The relevant part of the recorder trace of force versus time is obtained when the specimen is held stationary in the immersed position.

NOTE The specimen should be immersed to the required depth within 0,2 s.

The trace shall be recorded starting immediately before immersion into molten solder and throughout test period.

Table 1 – Time sequence of the test

Procedure	Time s	Duration s
1) Immersion in flux	0	≈5
2) Flux drain	≈10	1 to 5
3) Hang the specimen on the apparatus	≈15	--
4) Preheat	≈20	30 ± 15
5) Wipe the oxide from the solder surface	≈60	
6) Start test	≈65	1 to 5
7) Solder immersion	70 max.	5
NOTE Time is elapsed time from immersion in flux. Duration is time for relevant procedure.		

9 Presentation of results

9.1 Form of chart-recorder trace

The trace may be recorded in two forms, the only difference being the polarity of the force readings.

In Figure 2, upward forces (non-wetting) are shown as negative and downward forces (wetting) are positive. Usually, force at *E* is equal to force at *D* indicating stable wetting conditions. If force at *E* is less than at *D*, some instability in wetting is present (see B.6.1.3).

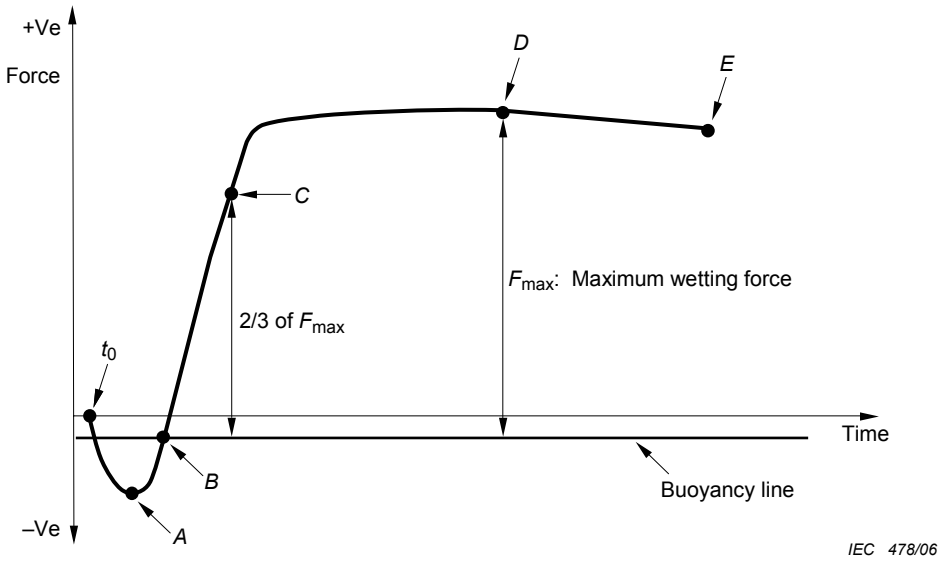

Figure 2 – Wetting conditions

9.2 Points of significance

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

9.2.2 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.

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

9.2.4 At point *C* the wetting force reaches two-thirds of the maximum value of the resultant wetting force. At point *C*, the wetting force shall exceed a specified value within a specified time.

9.2.5 Point *D* is the maximum value of the resultant wetting force is reached during the specified immersion period.

9.2.6 Point *E* is the point at the end of the specified immersion period. Points *D* and *E* may have the same force value on the same specimen (see B.6.1.3).

9.2.7 Interpretation of the trace formed during the withdrawal of the specimen is not considered in the stationary mode.

9.3 Reference wetting force

In order to obtain a practical reference against which to compare experimental results, the following procedure shall be carried out for each kind of component to be tested.

A specimen is taken from the sample to be tested and is pre-tinned under optimum conditions using the activated flux (refer to 7.2). This pre-tinning can be done on the wetting balance, set at the same conditions as are used for the wetting test. The procedure of pre-tinning shall be repeated on the same specimen till the maximum force reading does not further increase. The reference wetting force is this maximum force.

In order to investigate the general suitability for soldering of a certain material, the reference wetting force can be compared with the theoretical wetting force obtained by calculation under the assumptions of an appropriate surface tension constant and density of the solder alloy, together with the occurrence of "perfect" wetting.

The theoretical wetting force is obtained from the formula:

$$F = -g\rho v + \gamma P$$

where

g is the acceleration of gravity

ρ is the density of the solder

γ is the surface constant of the solder; and

F is obtained in mN, if

v the volume of the immersed part of the specimen, is given in cubic millimetres

P the perimeter of the immersed part of the specimen, is given in millimetres.

NOTE The formula is appropriate only if the cross-section of the specimen in the vicinity of the meniscus is constant through the length of the specimen. The constants are applicable only to the conditions described in the test. It is dependent on the alloy, temperature and flux (see B.6.2).

9.4 Test requirements

Requirements for solderability shall be expressed in terms of one or more of the following parameters:

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

10 Information to be given in the relevant specification

When a solderability test by the wetting balance method is specified the following details shall be defined:

Annex A
(normative)

Equipment specification

For specification purposes the complete apparatus, including the chart recorder, shall be considered as a single piece of equipment having the following characteristics.

A.1 The response time of the writing device of the chart recorder shall be such that its return to centre zero on removal of a maximum load shall be accomplished within 0,3 s, with an overshoot not exceeding 1 % of the corresponding maximum reading.

A.2 The instrument system should have a number of sensitivity settings. On the most sensitive range, the maximum deflection from centre shall be obtainable by suspending a mass not exceeding 200 mg in the specimen holder.

A.3 The chart speed shall be not less than 10 mm/s.

A.4 Electrical and mechanical noise recorded in the trace shall not exceed the equivalent of 0,04 mN.

A.5 The deflection of the writing device shall be directly proportional to the force being measured over the full scale to an accuracy of better than 95 %.

A.6 The stiffness of the spring system of the mechanical balance shall be such that a load of 10 mN causes a vertical displacement of the specimen suspension not exceeding 0,1 mm.

A.7 The dimensions of the solder bath shall be such that no portion of the specimen is less than 15 mm from the wall, and the depth of the bath shall be not less than 15 mm.

A.8 The bath temperature shall be maintained, as specified in 8.1.

A.9 The immersion depth of the lowest point on the specimen shall be adjustable to any specified position between 2 mm and 5 mm with a maximum error of ± 0,2 mm.

A.10 The speed of immersion shall be 5 mm/s ± 1 mm/s to 20 mm/s ± 1 mm/s for the stationary mode.

A.11 The dwell time at the maximum immersion depth shall be adjustable from 0 s to 10 s.

Annex B
(informative)

Guide to the use of the wetting balance for solderability testing

B.1 Definition of the measure of "wettability"

The wetting balance method permits the measurement of the vertical forces acting on a specimen as a function of time, when it is immersed in a bath of molten solder. The wettability 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.

A specification for wettability may require that several points on the force-time curve conform to particular values. This guide suggests points and values that may be used.

The test equipment must 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 explained here.

B.2 Specimen shape

The specimen may be of any shape, but in order to simplify the interpretation of the curve and the calculation of forces, it is preferable for the immersed portion of the specimen to be of uniform cross-section. To reduce errors in calculation, the specimen should be immersed with the surfaces to be tested within an angle ±15° from the vertical and, if the immersed end of the specimen has to be cut, it must be cut at right angles to the vertical axis and be free of burrs.

The test can be applied to such specimens as chip capacitors or samples of printed circuit board having large areas not wettable by solder. However, such areas may produce distortion of the force-time curve. For this reason, the present standard is directed to the use of the method in testing component terminations designed to be capable of being wetted by solder round the entire perimeter of cross-section.

B.3 Specimen preparation

It is important that a standard procedure for fluxing and draining the specimens is used so that the trace is not disturbed by the effects of solvent evaporation or dripping of flux during the course of the test.

B.4 Characteristics of test apparatus

B.4.1 Recording device

B.4.1.1 Zero setting

During the test cycle, the force acting on the specimen reverses direction as non-wetting changes to a wetted condition. In certain cases the buoyancy force may cause a considerable vertical displacement of the recorded wetting trace. Therefore, in order to record the whole sweep of the wetting trace at the highest possible sensitivity, it is necessary to operate the chart recorder with a zero that is at the centre of the chart, or off-set to a level consistent with keeping the whole curve on the chart.

B.4.1.2 **Response time** (see Clause A.1)

The response time must be small enough to ensure that the recording device 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 the recording device.

The following procedure is used for testing the response time of the instrument and zero stability. It requires the use of a known mass (which should be sufficient to give a full-scale deflection of the recorder pen from the mid-point zero) and a specimen holder of a shape suitable to carry it.

– With the specimen holder in position, set the recorder to zero.
– Start the chart moving at its maximum speed setting.
– Place the mass on the specimen holder.
– After 2 s or 3 s remove the mass, leaving the chart still running.
– After 2 s or 3 s more, replace the mass on the holder.
– Repeat the operation at least 5 times or 6 times, and switch off the chart drive.

The trace obtained on the chart will give the sensitivity of the instrument for the chosen settings, the time required for the pen to respond, and the consistency of its return to the zero position.

B.4.1.3 **Sensitivity settings** (see Clause A.2)

The provision of a range of sensitivity settings allows specimens of different sizes to be tested. Such a range is conveniently obtained by means of a chart recorder with a variety of amplifier settings. If these settings allow full-scale presentation of forces between 20 mN and 1 mN (corresponding to added masses of 2 g and 100 mg), specimens having a perimeter between 20 mm and 1 mm can be accommodated.

B.4.1.4 **Chart speed** (see Clause A.3)

A minimum chart speed of 10 mm/s is necessary to allow sufficient discrimination of the important points on the force-time curve.

B.4.2 Balance system

B.4.2.1 **Stiffness of spring** (see Clause A.6)

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 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 the other forces being measured.

B.4.2.2 **Noise level** (see Clause A.4)

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

B.4.3 **Solder bath** (see Clause A.7)

The bath must be of sufficient thermal mass to enable the test temperature to be maintained to the required precision. The specimen must be sufficiently distant from the walls of the bath such that the forces acting on it are not affected by curvature of the solder surface at the edges. The bath temperature, as specified in 8.1, is chosen in order to enhance the discrimination offered by the test.

Certain coating dissolve into solder alloy during the test as impurities or shifting composition of the solder alloy. Impurities in solder or shifted composition may change solderability property of solder alloy and affect the trace of force. Therefore, it is strongly recommended to verify solder alloy composition in the solder bath to ensure within the limit.

B.4.4 Bath lifting mechanism and controls

B.4.4.1 **Depth of immersion** (see Clause A.9)

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 rising solder meniscus traverses the region of interest. It may be necessary to trim off the end of the specimen in order to achieve this or to maintain a clearance from the bottom of the solder bath.

b) The traverse should preferably be over a length of uniform cross-section.

c) Depth of immersion shall be reproducible to within 0,2 mm to ensure that the buoyancy correction (which is in general small) is consistent to within ± 10 % in the worst case.

NOTE The deeper the immersion, the more the buoyancy offsets the zero force level from the centre zero until, even for perfect wetting, the final signal may remain above the initial balance point.

The deeper the immersion, 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.4.4.2 **Speed of immersion** (see Clause A.10)

For the standard mode of operation, it has been found that 16 mm/s to 25 mm/s is a satisfactory compromise between a speed so fast that shock waves are produced in the solder bath (which interfere with the force measurements) and one so slow that the solder bath is still moving during the important initial period of the meniscus rise.

B.4.4.3 **Duration of immersion** (see Clause A.11)

Specimens where the soldering process takes longer than 10 s will in general be unacceptable. However, a dwell time of less than 10 s may not allow time to collect sufficient information on specimens of poor solderability or large thermal capacity. A dwell time of 5 s will usually be found sufficient for small specimens such as lead-wires.

Comparison between the force value recorded early in the test cycle with that at the end of the dwell time can provide information on the stability of the interface between the solder and the specimen. See also B.6.1.3.

B.5 Some representative force-time curves

In these examples, 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.

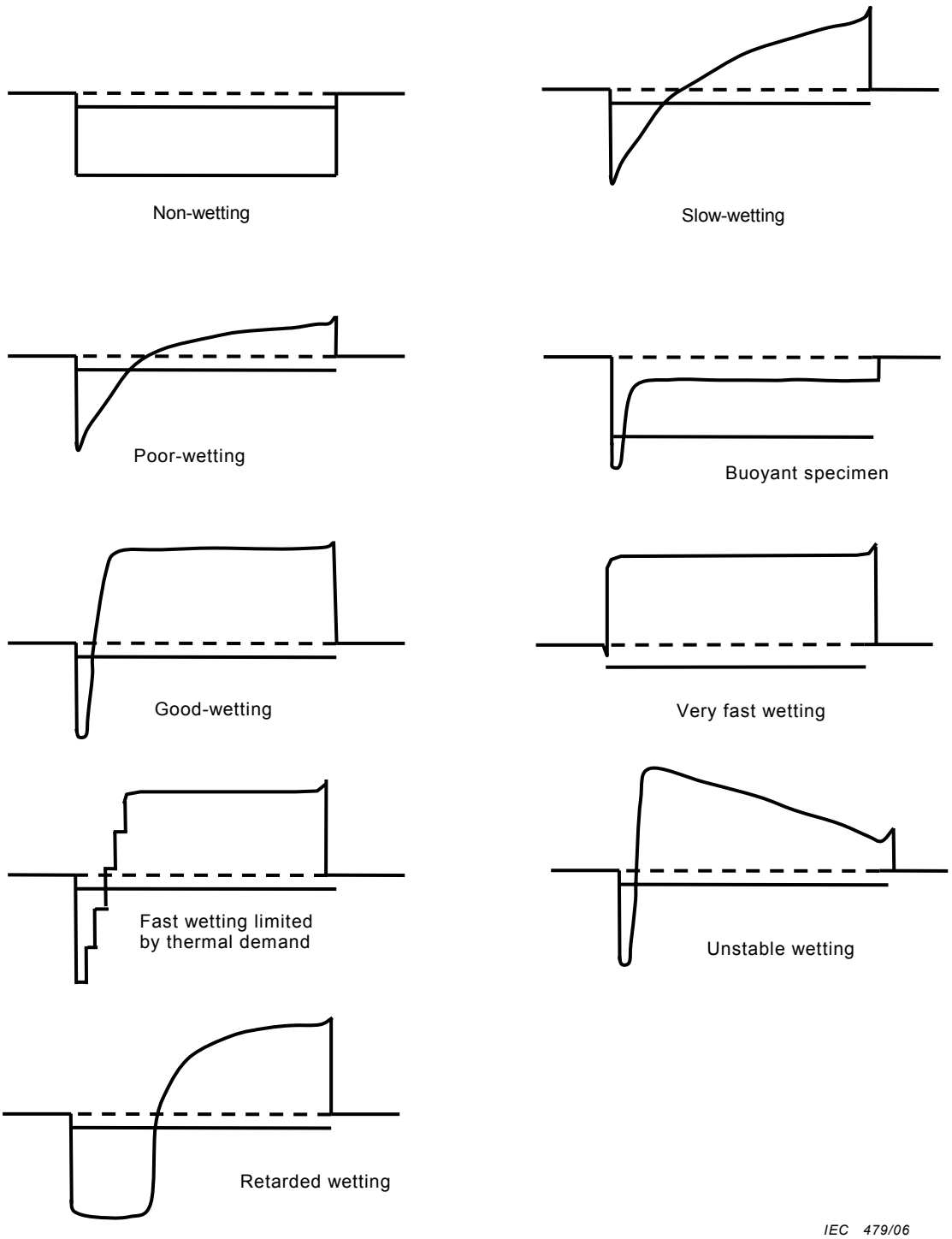

Figure B.1 – Representative force-time curves

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/cm^3 should be used for the density of molten solder with 60 % tin and 40 % lead. For SnAgCu and SnCu solder alloys, the density of molten solder rounded-off value of 7,1 g/cm^3 should be used.

B.6 Parameters to be measured from the force-time trace

B.6.1 Choice of test criteria

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

B.6.1.1 Time for onset of wetting

At point *B* (see Figure 2), the wetting process has advanced from a non-wetting state to the point where the solder meniscus is about to start to rise above the level of the solder bath. The time interval between *B* and t_0 is thus the time for the onset of wetting. It is recommended that, for components to be assembled by a mass soldering process, this time should be required to be in the order of 1 s to 2,5 s, depending on the type of flux and the thermal characteristic of the specimen.

B.6.1.2 Progress of wetting

The maximum wetting force is the maximum value obtained during a test. The reference wetting force is the maximum value obtainable with a given system.

The measured force at a given time, or the time to reach a given force, should meet the specified requirement.

B.6.1.3 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 be evaporated or decomposed or migrate over the surface of the solder bath. 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.

For test periods of 5 s to 10 s it is therefore recommended that the ratio $\frac{\text{force at } E}{\text{force at } D}$ should be required to exceed 0,8.

B.6.2 Reference wetting force

The procedure described in 9.3 for determining a reference wetting force utilizes treatments which provide favourable conditions for the wetting of the surfaces to be tested.

In using such a measured reference value, the results of tests on specimens with unknown surface condition are compared with the best wetting value that the material is capable of showing in the given geometry and under conditions defined in the test.

If this procedure is applied to materials that are inherently difficult to wet with solder, the measured reference force so obtained sets a standard that represents a too low degree of wetting. In such cases the specimens certainly fail the first requirement: t_0 to *B*.

In order to obtain a wetting standard that is independent of the specimen, the practical reference wetting force can be compared with a theoretical wetting force obtained by calculation, using the formula:

$$F_{(\mathrm{mN})} = -gpv + \gamma P$$

where

P is the perimeter of the immersed part of the specimen (in millimetres); and

v is the volume of the immersed part of the specimen (in cubic millimetres).

This relationship is based on the assumptions that

a) the theoretical wetting force *F* acts in the plane of the specimen surface (i.e. zero angle of contact);

b) the surface tension constant γ appropriate for the specified flux and solder at test temperature is 0,4 mN/mm for SnPb solder alloys and 0,47 mN/mm for SnAgCu and SnCu solder alloys;

c) the product *gp* (where *g* is the acceleration of gravity and *p* is the solder density at test temperature) can be approximated to 0,08 N/cm^3 (SnPb solder alloys) or 0,07 N/cm^3 (SnAgCu and SnCu solder alloys) for the purposes of this calculation.

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Thank you for your contribution to the standards-making process.

Nicht frankieren
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A Prioritaire

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.....

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researcher ❑
design engineer ❑
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testing engineer ❑
marketing specialist ❑
other.....

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not at all ❑
nearly ❑
fairly well ❑
exactly ❑

Q6 If you ticked NOT AT ALL in Question 5 the reason is: *(tick all that apply)*

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standard is incomplete ❑
standard is too academic ❑
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(2) below average,
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