BS EN 61189-5-3:2015

BSI Standards Publication

Test methods for electrical materials, printed boards and other interconnection structures and assemblies

Part 5-3: General test methods for materials and assemblies — Soldering paste for printed board assemblies

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 61189-5-3:2015. It is identical to IEC 61189-5-3:2015. It supersedes BS IEC 61189-5-3:2015, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EPL/501, Electronic Assembly Technology.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2015

ISBN 978 0 580 90019 8

ICS 31.180

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2015.

Amendments/corrigenda issued since publication

Date	Text affected
30 April 2015	This corrigendum renumbers BS IEC 61189-5-3:2015 as BS EN 61189-5-3:2015

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 61189-5-3

March 2015

ICS 31.180

English Version

Test methods for electrical materials, printed boards and other interconnection structures and assemblies - Part 5-3: General test methods for materials and assemblies - Soldering paste for printed board assemblies (IEC 61189-5-3:2015)

Méthodes d'essai pour les matériaux électriques, les cartes imprimées et autres structures d'interconnexion et ensembles - Partie 5-3: Méthodes d'essai générales pour les matériaux et les assemblages - Pâte de brasage pour les assemblages de cartes imprimées (IEC 61189-5-3:2015)

Prüfverfahren für Elektromaterialien, Leiterplatten und andere Verbindungsstrukturen und Baugruppen - Teil 5-3: Allgemeine Prüfverfahren für Materialien und Baugruppen - Lotpaste für bestückte Leiterplatten (IEC 61189-5-3:2015)

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 61189-5-3:2015 E

Foreword

The text of document 91/1211/FDIS, future edition 1 of IEC 61189-5-3, prepared by IEC/TC 91 "Electronics assembly technology" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61189-5-3:2015.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-11-12
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2018-02-12

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61189-5-3:2015 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068-1:2013	NOTE	Harmonized as EN 60068-1:2014 (not modified).
IEC 60068-2-20	NOTE	Harmonized as EN 60068-2-20.
IEC 61189-1	NOTE	Harmonized as EN 61189-1.
IEC 61189-2	NOTE	Harmonized as EN 61189-2.
IEC 61189-3	NOTE	Harmonized as EN 61189-3.
IEC 61190-1-1	NOTE	Harmonized as EN 61190-1-1.
IEC 61249-2-7	NOTE	Harmonized as EN 61249-2-7.
IEC 62137:2004	NOTE	Harmonized as EN 62137:2004 (not modified).
ISO 9001	NOTE	Harmonized as EN ISO 9001.
ISO 9455-2	NOTE	Harmonized as EN ISO 9455-2.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 61189-5	-	Test methods for electrical materials, interconnection structures and assemblies - Part 5: Test methods for printed board assemblies	EN 61189-5	-
IEC 61189-6	-	Test methods for electrical materials, interconnection structures and assemblies - Part 6: Test methods for materials used in manufacturing electronic assemblies	EN 61189-6	-
IEC 61190-1-2	2014	Attachment materials for electronic assembly - Part 1-2: Requirements for soldering pastes for high-quality interconnects in electronics assembly	EN 61190-1-2	2014
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	EN 61190-1-3	-

CONTENTS

FOREWORD 7
INTRODUCTION 9
1 Scope 10
2 Normative references 10
3 Accuracy, precision and resolution 10
3.1 General 10
3.2 Accuracy 11
3.3 Precision 11
3.4 Resolution 12
3.5 Report 12
3.6 Student's t distribution 12
3.7 Suggested uncertainty limits 13
4 X: Miscellaneous test methods 14
4.1 Test 5-3X01: Paste flux viscosity – T-Bar spindle method 14
4.1.1 Object 14
4.1.2 Test specimen 14
4.1.3 Apparatus and reagents 14
4.1.4 Procedure 14
4.1.5 Safety notes 14
4.2 Test 5-3X02: Spread test, extracted solder flux, paste flux and solder paste 14
4.2.1 Object 14
4.2.2 Method A 15
4.2.3 Method B 16
4.2.4 Additional information 17
4.3 Test 5-3X03: Solder paste viscosity – T-Bar spin spindle method (applicable for 300 Pa·s to 1 600 Pa·s) 17
4.3.1 Object 17
4.3.2 Test specimen 17
4.3.3 Equipment/apparatus 17
4.3.4 Procedure 18
4.3.5 Evaluation 18
4.3.6 Additional information 18
4.4 Test 5-3X04: Solder paste viscosity – T-Bar spindle method (applicable to 300 Pa·s) 18
4.4.1 Object 18
4.4.2 Test specimen 19
4.4.3 Equipment/apparatus 19
4.4.4 Procedure 19
4.4.5 Evaluation 19
4.4.6 Additional information 19
4.5 Test 5-3X05: Solder paste viscosity – Spiral pump method (applicable for 300 Pa·s to 1 600 Pa·s) 20
4.5.1 Object 20
4.5.2 Test specimen 20
4.5.3 Equipment/apparatus 20
4.5.4 Procedure 20

4.5.5 Evaluation 20
4.5.6 Additional information 20
4.6 Test 5-3X06: Solder paste viscosity – Spiral pump method (applicable to 300 Pa·s) 21
4.6.1 Object 21
4.6.2 Test specimen 21
4.6.3 Equipment/apparatus 21
4.6.4 Procedure 21
4.6.5 Evaluation 21
4.6.6 Additional information 21
4.7 Test 5-3X07: Solder paste – Slump test 22
4.7.1 Object 22
4.7.2 Test specimen 22
4.7.3 Equipment/apparatus 22
4.7.4 Procedure 22
4.7.5 Evaluation 24
4.8 Test 5-3X08: Solder paste – Solder ball test 24
4.8.1 Object 24
4.8.2 Test specimen 25
4.8.3 Equipment/apparatus 25
4.8.4 Procedure 25
4.8.5 Evaluation 26
4.9 Test 5-3X09: Solder paste – Tack test 27
4.9.1 Object 27
4.9.2 Method A 27
4.9.3 Method B 28
4.9.4 Test equipment sources 29
4.10 Test 5-3X10: Solder paste – Wetting test 29
4.10.1 Object 29
4.10.2 Test specimen 29
4.10.3 Equipment/materials/apparatus 29
4.10.4 Procedure 29
4.10.5 Evaluation 30
4.11 Test 5-3X11: Determination of solder powder particle size distribution – Screen method for types 1-4 30
4.11.1 Object 30
4.11.2 Test specimen 30
4.11.3 Equipment/apparatus 30
4.11.4 Procedure 30
4.12 Test 5-3X12: Solder powder particle size distribution – Measuring microscope method 32
4.12.1 Object 32
4.12.2 Test specimen 32
4.12.3 Equipment/apparatus 32
4.12.4 Procedure 32
4.13 Test 5-3X13: Solder powder particle size distribution – Optical image analyser method 33
4.13.1 Object 33
4.13.2 Test specimen 33
4.13.3 Equipment/apparatus 33

4.13.4 Procedure 34
4.14 Test 5-3X14: Solder powder particle size distribution – Measuring laser diffraction method 35
4.14.1 Object 35
4.14.2 Test specimen 35
4.14.3 Equipment/apparatus 35
4.14.4 Preparation 36
4.14.5 Test procedure 36
4.14.6 Test 36
4.14.7 Evaluation 36
4.15 Test 5-3X15: Determination of maximum solder powder particle size 37
4.15.1 Object 37
4.15.2 Test specimen 37
4.15.3 Evaluation 37
4.16 Test 5-3X16: Solder paste metal content by weight 38
4.16.1 Object 38
4.16.2 Test specimen 38
4.16.3 Equipment/apparatus 38
4.16.4 Procedure 38
Annex A (informative) Typical comparison of particle size distributions between laser diffraction method and screen method 40
Bibliography 41

Figure 1 – Slump test stencil thickness, 0,20 mm 23
Figure 2 – Slump test stencil thickness, 0,10 mm 23
Figure 3 – Solder-ball test evaluation 26
Figure 4 – Solder wetting examples 30
Figure A.1 – Typical comparison between laser diffraction and sieving 40

Table 1 – Student's t distribution 13
Table 2 – Typical spread areas defined in mm^2 15
Table 3 – Example of a test report – Stencil thickness, 0,2 mm 24
Table 4 – Example of a test report – Stencil thickness, 0,1 mm 24
Table 5 – Screen opening 31
Table 6 – Portions of particle sizes by weight % – nominal values 32
Table 7 – Powder particle size distribution record 32
Table 8 – Powder particle size distribution record 33
Table 9 – Powder particle size distribution record (optical analysis) 35
Table 10 – Powder particle size distribution record 36
Table 11 – Acceptance of powders by particle sizes 38
Table 12 – Example of a test report on solder paste 39

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –

Part 5-3: General test methods for materials and assemblies – Soldering paste for printed board assemblies

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61189-5-3 has been prepared by IEC technical committee 91: Electronics assembly technology.

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

FDIS	Report on voting
91/1211/FDIS	91/1224/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.

This International Standard is used in conjunction with IEC 61189-1:1997, IEC 61189-2:2006, IEC 61189-3:2007.

A list of all parts in the IEC 61189 series, published under the general title *Test methods for electrical materials, printed boards and other interconnection structures and assemblies*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC 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.

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

INTRODUCTION

IEC 61189 relates to test methods for materials or component robustness for printed board assemblies, irrespective of their method of manufacture.

The standard is divided into separate parts, covering information for the designer and the test methodology engineer or technician. Each part has a specific focus; methods are grouped according to their application and numbered sequentially as they are developed and released.

In some instances test methods developed by other TCs (for example, TC 104) have been reproduced from existing IEC standards in order to provide the reader with a comprehensive set of test methods. When this situation occurs, it will be noted on the specific test method; if the test method is reproduced with minor revision, those paragraphs that are different are identified.

This part of IEC 61189 contains test methods for evaluating robustness of materials or components for printed board assemblies. The methods are self-contained, with sufficient detail and description so as to achieve uniformity and reproducibility in the procedures and test methodologies.

The tests shown in this standard are grouped according to the following principles:

P: preparation/conditioning methods

V: visual test methods

D: dimensional test methods

C: chemical test methods

M: mechanical test methods

E: electrical test methods

N: environmental test methods

X: miscellaneous test methods

To facilitate reference to the tests, to retain consistency of presentation, and to provide for future expansion, each test is identified by a number (assigned sequentially) added to the prefix (group code) letter showing the group to which the test method belongs.

The test method numbers have no significance with respect to an eventual test sequence; that responsibility rests with the relevant specification that calls for the method being performed. The relevant specification, in most instances, also describes pass/fail criteria.

The letter and number combinations are for reference purposes to be used by the relevant specification. Thus "5-3X01" represents the first chemical test method described in IEC 61189-5-3.

In short, in this example, 5-3 is the number of the part of IEC 61189, X is the group of methods, and 01 is the test number.

TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –

Part 5-3: General test methods for materials and assemblies – Soldering paste for printed board assemblies

1 Scope

This part of IEC 61189 is a catalogue of test methods representing methodologies and procedures that can be applied to test printed board assemblies.

This part of IEC 61189 focuses on test methods for soldering paste based on the existing IEC 61189-5 and IEC 61189-6. In addition, it includes test methods of soldering paste for lead free soldering.

2 Normative references

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

IEC 61189-5, *Test methods for electrical materials, interconnection structures and assemblies – Part 5: Test methods for printed board assemblies*

IEC 61189-6, *Test methods for electrical materials, interconnection structures and assemblies – Part 6: Test methods for materials used in manufacturing electronic assemblies*

IEC 61190-1-2:2014, *Attachment materials for electronic assembly – Part 1-2: Requirements for soldering pastes for high-quality interconnections in electronics assembly*

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 Accuracy, precision and resolution

3.1 General

Errors and uncertainties are inherent in all measurement processes. The information given below enables valid estimates of the amount of error and uncertainty to be taken into account.

Test data serve a number of purposes which include

– monitoring of a process;
– enhancing of confidence in quality conformance;
– arbitration between customer and supplier.

In any of these circumstances, it is essential that confidence can be placed upon the test data in terms of

– accuracy: calibration of the test instruments and/or system;
– precision: the repeatability and uncertainty of the measurement;
– resolution: the suitability of the test instrument and/or system.

3.2 Accuracy

The regime by which routine calibration of the test equipment is undertaken shall be clearly stated in the quality documentation of the supplier or agency conducting the test and should meet the requirements of ISO 9001.

The calibration shall be conducted by an agency having accreditation to a national or international measurement standard institute. There should be an uninterrupted chain of calibration to a national or international standard.

Where calibration to a national or international standard is not possible, round-robin techniques may be used and documented to enhance confidence in measurement accuracy.

The calibration interval shall normally be one year. Equipment consistently found to be outside acceptable limits of accuracy shall be subject to shortened calibration intervals. Equipment consistently found to be well within acceptable limits may be subject to relaxed calibration intervals.

A record of the calibration and maintenance history shall be maintained for each instrument. These records should state the uncertainty of the calibration technique (in ± % deviation) in order that uncertainties of measurement can be aggregated and determined.

A procedure shall be implemented to resolve any situation where an instrument is found to be outside calibration limits.

3.3 Precision

The uncertainty budget of any measurement technique is made up of both systematic and random uncertainties. All estimates shall be based upon a single confidence level, the minimum being 95 %.

Systematic uncertainties are usually the predominant contributor and will include all uncertainties not subject to random fluctuation. These include

– calibration uncertainties;
– errors due to the use of an instrument under conditions which differ from those under which it was calibrated;
– errors in the graduation of a scale of an analogue meter (scale shape error).

Random uncertainties result from numerous sources but can be deduced from repeated measurement of a standard item. Therefore, it is not necessary to isolate the individual contributions. These may include

– random fluctuations such as those due to the variation of an influence parameter. Typically, changes in atmospheric conditions reduce the repeatability of a measurement;
– uncertainty in discrimination, such as setting a pointer to a fiducial mark or interpolating between graduations on an analogue scale.

Aggregation of uncertainties: Geometric addition (root-sum-square) of uncertainties may be used in most cases. Interpolation error is normally added separately and may be accepted as being 20 % of the difference between the finest graduations of the scale of the instrument.

$$U_{\mathrm{t}} = \pm\sqrt{(U_{\mathrm{s}}^2 + U_{\mathrm{r}}^2)} + U_{\mathrm{i}}$$

where

U_t is the total uncertainty;

U_s is the systematic uncertainty;

U_r is the random uncertainty;

U_i is the interpolation error.

Determination of random uncertainties: Random uncertainty can be determined by repeated measurement of a parameter and subsequent statistical manipulation of the measured data. The technique assumes that the data exhibits a normal (Gaussian) distribution.

$$U_r = \frac{t \times \sigma}{\sqrt{n}}$$

where

U_r is the random uncertainty;

n is the sample size;

t is the percentage point of the t distribution as shown in Table 1;

σ is the standard deviation (σ_{n-1}).

3.4 Resolution

It is paramount that the test equipment used be capable of sufficient resolution. Measurement systems used should be capable of resolving 10 % (or better) of the test limit tolerance.

It is accepted that some technologies will place a physical limitation upon resolution (for example, optical resolution).

3.5 Report

In addition to the requirements detailed in the test specification, the report shall detail

a) the test method used;
b) the identity of the sample(s);
c) the test instrumentation;
d) the specified limit(s);
e) an estimate of measurement uncertainty and resultant working limit(s) for the test;
f) the detailed test results;
g) the test date and operators' signature.

3.6 Student's *t* distribution

Table 1 gives values of the factor t for 95 % and 99 % confidence levels, as a function of the number of measurements.

Table 1 – Student's *t* distribution

Sample size	*t* value 95 %	*t* value 99 %		Sample size	*t* value 95 %	*t* value 99 %
2	12,7	63,7		14	2,16	3,01
3	4,3	9,92		15	2,14	2,98
4	3,18	5,84		16	2,13	2,95
5	2,78	4,6		17	2,12	2,92
6	2,57	4,03		18	2,11	2,9
7	2,45	3,71		19	2,1	2,88
8	2,36	3,5		20	2,09	2,86
9	2,31	3,36		21	2,08	2,83
10	2,26	3,25		22	2,075	2,82
11	2,23	3,17		23	2,07	2,81
12	2,2	3,11		24	2,065	2,8
13	2,18	3,05		25	2,06	2,79

3.7 Suggested uncertainty limits

The following target uncertainties are suggested:

a) Voltage < 1 kV: ± 1,5 %
b) Voltage > 1 kV: ± 2,5 %
c) Current < 20 A: ± 1,5 %
d) Current > 20 A: ± 2,5 %

Resistance

e) Earth and continuity: ± 10 %
f) Insulation: ± 10 %
g) Frequency: ± 0,2 %

Time

h) Interval < 60 s: ± 1 s
i) Interval > 60 s: ± 2 %
j) Mass < 10 g: ± 0,5 %
k) Mass 10 g – 100 g: ± 1 %
l) Mass > 100 g: ± 2 %
m) Force: ± 2 %
n) Dimension < 25 mm: ± 0,5 %
o) Dimension > 25 mm: ± 0,1 mm
p) Temperature < 100 °C: ± 1,5 %
q) Temperature > 100 °C: ± 3,5 %
r) Humidity (30 – 75) % RH: ± 5 % RH

Plating thicknesses

s) Backscatter method: ± 10 %
t) Microsection: ± 2 microns

u) Ionic contamination: ± 10 %

4 X: Miscellaneous test methods

4.1 Test 5-3X01: Paste flux viscosity – T-Bar spindle method

4.1.1 Object

This test method is designed to measure the viscosity of paste flux.

4.1.2 Test specimen

The test specimen shall contain enough paste flux to fill a container with a minimum diameter of 4 cm to a minimum depth of approximately 10 cm.

4.1.3 Apparatus and reagents

a) Viscometer with helipath stand and a T-C spindle (Brookfield RVTD[1] or equivalent).

b) Water bath capable of holding (25 ± 0,5) °C.

c) Stopwatch.

d) Spatula.

4.1.4 Procedure

4.1.4.1 Test

a) Place the container of paste flux in the water bath at (25 ± 0,5) °C.

b) When the medium has attained thermal equilibrium, place the container under the spindle so that it is at the centre of the surface.

c) Start the Brookfield at 5 r/min and start the helipath stand on descent.

d) Record the value 2 min after the spindle has cut into the top surface of the medium. Check that the spindle is not touching the bottom of the container.

e) Remove the spindle from the paste flux. Using the spatula, stir the flux vigorously for (15-20) s and re-measure the viscosity.

4.1.4.2 Expression of results

The viscosities are calculated from the values recorded after 2 min of medium penetration. Both stirred and unstirred results should be recorded.

4.1.5 Safety notes

Observe all appropriate precautions on material safety data sheets (MSDS) for chemicals involved in this test method.

4.2 Test 5-3X02: Spread test, extracted solder flux, paste flux and solder paste

4.2.1 Object

This test method gives an indication of activity of solder paste. The test method offers two methods.

Method A measures the solder spread area.

---

[1] Brookfied RVTD is the trade name of a product supplied by Brookfield Engineering Laboratories, Inc. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Method B measures the solder spread ratio.

4.2.2 Method A

4.2.2.1 Test specimen

a) For extracted solder flux, a minimum of 10 ml that is furnished in a clean glass container.

b) For paste flux and solder paste flux, 10 ml of the diluted material (35 %).

4.2.2.2 Apparatus and reagents

a) Five replicates of 0,25 mm thick 70/30 brass of a size of approximately 40 mm × 75 mm.

b) Degreased very fine steel wool (for example, #00).

c) Solder wire from Sn63Pb37A, or Sn96.5Ag3Cu0.5, or any other solder alloy wire agreed between the user and the supplier per IEC 61190-1-3 with a diameter of 1,5 mm.

d) A solder pot not less than 25 mm in depth containing at least 2 kg solder.

4.2.2.3 Test specimen preparation

a) Clean five brass coupons with steel wool.

b) Flatten the brass coupon by bending the opposite sides of the coupon. The two bends should be parallel to the curve of the metal coil in which the brass was provided in order to stiffen and flatten the test specimen.

c) Cut a 30 mm length of solid wire solder.

d) Wrap the cut length of solder around a 3 mm mandrel.

e) Cut the coil into individual rings to make a preform of the solder.

4.2.2.4 Test

a) Maintain the solder bath at (260 ± 3) °C for Sn60Pb40, or at (255 ± 3) °C for Sn96.5Ag3Cu0.5, or at (35 ± 3) °C higher than the liquidus temperature for any other solder alloy agreed between the user and the supplier .

b) Place the preformed solder on the centre of the test specimen.

c) Place one drop (0,05 ml) of flux on the centre of the preform of the test specimen.

d) Carefully place the coupon on the surface of the solder bath for 15 s.

e) Remove the coupon in a horizontal position and place on a flat surface allowing the adhered solder to solidify undisturbed.

f) Remove all flux residue with a suitable solvent.

4.2.2.5 Evaluation

Measure the solder spread area by comparing to circles (pre-drawn) with areas similar to those listed in Table 2. The mean of the spread of all five specimens tested shall be reported. Record the data and enter it in Table 12.

Table 2 is intended as an aid in defining areas in mm^2.

Table 2 – Typical spread areas defined in mm^2

Diameter mm	Area mm^2
10,00	78,54
10,70	90,00
11,28	100,00

4.2.3 Method B

4.2.3.1 Test specimen

a) Flux may be used from several products. These may be solder paste and paste flux.

b) Solder wire of Sn63Pb37, or Sn96.5Ag3Cu0.5, or any other solder alloy agreed between the user and the supplier specified in IEC 61190-1-3 shall be wrapped on a ring bar with a diameter of 3,3 mm.

4.2.3.2 Apparatus and reagents

a) Solder bath: A solder bath with a depth of not less than 30 mm, 100 mm × 150 mm or more in width and length, provided with a temperature controller up to (50 ± 2) °C above the liquidus temperature of the tested solder.

b) Dryer: An air convection oven with a temperature controller up to (150 ± 3) °C and capable of maintaining the temperature.

c) Tongue of other proper tool suitable to lift up the test piece from the solder bath.

d) Scrubber: Suitable to remove easily the oxidized film of solder in the bath.

e) Spatula.

f) Metal mask: Thickness of 2,5 mm with a hole of 6 mm diameter.

g) Micrometer: Measurable to 0,001 mm.

h) Micro syringe or micro pipet: Measurable of 0,05 ml.

i) General experimental device: All-glass device.

j) Abrasive paper (waterproof).

k) Alcohol: Ethyl alcohol (reagent grade).

l) propan-2-ol (reagent grade).

m) Washing solvent: Proper solvent to remove the flux residue after soldering.

n) Copper plate: A plate of 50 mm × 50 mm × 0,5 mm dimensions of dephosphate copper (to prevent surface oxidation).

o) Solder: Sn63Pb37, or Sn96.5Ag3Cu0.5, or any other solder alloy agreed between the user and the supplier specified in IEC 61190-1-3 as reference specimen.

4.2.3.3 Test specimen preparation

4.2.3.3.1 Procedure of test

a) Preparation of an oxidated copper plate: the surface shall be cleaned with alcohol. One side of the plate shall be polished by abrasive paper, cleaned with alcohol, and dried thoroughly at room temperature. Put this plate into a dryer set at (150 ± 3) °C for 1 h and oxidate the plate. Four corners of the plate could be bent for easy application of a tongue.

b) Solder test specimen for liquid, solid and paste flux. Test specimen shall be one bar of 3,2 mm diameter on which wire solder of Sn63Pb37, or Sn96.5Ag3Cu0.5, or any other solder alloy agree with 1,6 mm diameter is wound.

c) Resin/rosin flux cored solder and solder paste. Product itself shall be used.

4.2.3.3.2 Preparation of test piece

a) Paste flux: Place (0,025 ± 0,003) g of specimen at the centre of the copper plate and place the solder test piece on it. Five test specimens shall be prepared.

b) Solder paste: After stirring with a spatula the solder paste kept at room temperature, apply to the copper plate with a metal mask. Five test specimens shall be prepared.

4.2.3.4 Test

a) The test piece shall be heated while floating on a solder bath kept at (233 ± 3) °C for Sn63Pb37, or at (255 ± 3) °C for Sn96.5Ag3Cu0.5, or at (35 ± 3) °C higher than the

liquidus temperature for any other solder alloy agreed between the user and the supplier, and kept at this temperature for 30 s after having fused.

b) Lift the test piece from the bath and cool it down.

c) Remove the flux residue by proper solvent.

4.2.3.5 Evaluation

The height of the spread solder fused shall be measured by a micrometer or other proper equipment. From this height, the spreading ratio shall be calculated from the formula shown below.

This procedure shall be repeated on five of the test pieces and a mean value shall be obtained, giving this as the spreading ratio of the flux representing solder under test.

$$S_R = 100 \times (D - H)/D$$

where

S_R is the spreading ratio (%);

H is the height of the spread solder (mm);

D is the diameter of the solder (mm), when it is assumed to be a sphere (mm) (D = 1,24 $V^{1/3}$);

V is the mass/density of the tested solder.

In the case of resin flux cored solder and solder paste, the mass of solder used for the test shall be the mass of the specimen subtracting the flux contained.

Record the data and enter it in Table 12.

4.2.4 Additional information

Safety: Observe all appropriate precautions on material safety data sheets (MSDS) for chemicals involved in this test method.

ASTM B-36 brass plate, sheet, strip, and rolled bar (according to ASTM-B-36 C2600 HO2; see Bibliography).

4.3 Test 5-3X03: Solder paste viscosity – T-Bar spin spindle method (applicable for 300 Pa·s to 1 600 Pa·s)

4.3.1 Object

The test specifies a standard procedure for determining the viscosity of solder paste in the range of 300 Pa·s to 1 600 Pa·s.

4.3.2 Test specimen

The paste to be tested shall be stabilized at (25 ± 1) °C for a minimum of 24 h prior to testing. The paste volume shall be sufficient to fill a test container having a minimum diameter of 5 cm and a minimum depth of 5 cm.

4.3.3 Equipment/apparatus

The equipment used shall consist of a spindle-type viscometer (Brookfield RVTD or equivalent) with a reversible helipath stand and pen recorder. A TF spindle shall be used for tests and operated at 5 r/min. Other equipment may be used provided the results can be empirically correlated as mutually agreed upon with the following test. Additional shear rates may be specified by the user or supplier.

4.3.4 Procedure

4.3.4.1 Preparation

a) Open the supply container(s); remove any internal cover(s), scrape off the paste adhering to the lid(s), internal covers, and the container walls; add this material to the paste in the supply container(s).

b) Using a spatula, stir the paste gently for 1 min to 2 min to homogenize it, taking care to avoid the introduction of air.

c) If necessary, gently transfer the paste to the test container having the specified volume without introducing air. Note that if the supply container meets the volume and size requirements, a separate test container is not needed.

d) The test container shall be placed in a constant temperature environment of (25 ± 0,25) °C. The solder paste shall remain stationary for a minimum of 2 h to reach temperature and rheological equilibrium. For freshly manufactured products, products which require significant adjustment with thinner (greater than 1/2 % by weight), or products having rheological characteristics requiring a longer time to stabilize, the stabilization time shall be increased to 4 h or as mutually agreed upon by user and supplier.

e) Set the bottom stop for helipath travel to position the T spindle at 2,8 cm below the surface of the solder paste in the test container. The bottom stop of the spindle shall be a minimum of 1 cm above the bottom of the container. Set the upper stop to position the spindle at 0,3 cm below the surface of the solder paste.

4.3.4.2 Test

Immerse the spindle in the solder paste and record data for 10 min (5 cycles). The temperature of the solder paste during the test shall be maintained at (25 ± 0,25) °C.

4.3.5 Evaluation

Viscosity shall be expressed as the value calculated from the average of the peak and valley of the last two cycles. If the average for the first two cycles is more than 10 % higher than the last two cycles, the test is invalid and additional equilibrium time is required. Record the data and enter it in Table 12.

4.3.6 Additional information

Test equipment sources: The equipment sources described below represent those currently known to the industry. Additional source names can be added when available.

Spindle Type Viscometer Equipment Brookfield Engineering Laboratories, Inc. 240 Cushing Street Stoughton, MA 02072 (617) 344-4310[2]

4.4 Test 5-3X04: Solder paste viscosity – T-Bar spindle method (applicable to 300 Pa·s)

4.4.1 Object

This test specifies a standard procedure for determining the viscosity of solder paste applicable to 300 Pa·s.

---

[2] This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4.4.2 Test specimen

Paste to be tested shall stabilize at (25 ± 1) °C for a minimum of 24 h prior to testing. The paste volume shall be sufficient to fill a test container having a minimum diameter of 5 cm and a minimum depth of 5 cm.

4.4.3 Equipment/apparatus

Equipment used shall be a spindle type viscometer (Brookfield RVTD[3] or equivalent) with a helipath stand and pen recorder. A TC spindle shall be used for tests. Spindle speed shall be 5 r/min. Other equipment may be used provided the results can be empirically correlated as mutually agreed upon with the following test. Additional shear rates may be specified by the user or supplier.

4.4.4 Procedure

4.4.4.1 Preparation

a) Open the supply container(s); remove any internal cover(s); scrape off the paste adhering to the lid(s), internal covers, and the container walls; and add this material to the paste in the supply container(s).

b) Using a spatula, stir the paste gently for 1 to 2 min to homogenize it, taking care to avoid the introduction of air.

c) If necessary, gently transfer the paste to the test container having the specified volume without introducing air.

NOTE If the supply container meets the volume and size requirements, a separate test container is not needed.

d) The test container shall be placed in a constant temperature environment of (25 ± 0,25) °C.

e) After reaching (25 ± 0,25) °C, the solder paste shall be stirred and then tested within 20 min to minimize the settling of the metal powder while remaining at 25 °C.

4.4.4.2 Test

Set the solder paste container below the spindle. Record data as the spindle penetrates the solder paste.

4.4.5 Evaluation

The viscosity is calculated from the value recorded after the bar of the spindle comes in contact with the surface of the paste. Record the data and enter it in Table 12.

4.4.6 Additional information

Test equipment sources: The equipment sources described below represent those currently known to the industry. Additional source names can be added when available.

Spindle Type Viscometer Equipment Brookfield Engineering Laboratories, Inc. 240 Cushing Street Stoughton, MA 02072 (617) 344-4310[4]

---

[3] Brookfied RVTD is the trade name of a product supplied by Brookfield Engineering Laboratories, Inc. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

[4] This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4.5 Test 5-3X05: Solder paste viscosity – Spiral pump method (applicable for 300 Pa·s to 1 600 Pa·s)

4.5.1 Object

The test specifies a standard procedure for determining the viscosity of solder paste for 300 Pa·s to 1 600 Pa·s.

4.5.2 Test specimen

The paste to be tested shall be stabilized at (25 ± 1) °C for a minimum of 24 h prior to testing. The paste volume shall be sufficient to fill the viscometer receptacle to about 60 % of its depth.

4.5.3 Equipment/apparatus

The equipment used shall be a spiral pump viscometer (Malcom, Brookfield Viscometer or Rheometer with spiral adaptor accessory, or equivalent). Set the instrument rotational speed to 10 r/min. Other equipment may be used provided the results can be empirically correlated as mutually agreed upon. Additional shear rates may be specified by the user or the supplier.

4.5.4 Procedure

4.5.4.1 Preparation

a) Open the container(s), remove any internal cover, scrape off the paste adhering to the lids or internal cover(s) and the container wall(s) and add this to the paste in the container(s).

b) Using a spatula, stir the paste gently for (1-2) min to homogenize it, taking care to avoid the introduction of air.

c) Transfer sufficient paste to the viscometer receptacle to fill this to about 60 % of its depth. Place the receptacle in the temperature controlled unit of the viscometer and allow it to stabilize at (25 ± 0,25) °C for 15 min minimum.

4.5.4.2 Test

a) Immerse the instrument sensor into the sample in accordance with the equipment manufacturer's instructions. The solder paste should not cover the pump outlet.

b) Turn on the chart recorder and set the instrument to run at one specific shear rate. Take a reading when the output has been stable for at least 1 min. If additional shear rates are to be measured, adjust the speed vernier and repeat the above.

c) Record the viscosity measured at the single-shear-rate value. By mutual agreement between user and supplier, multiple shear rates shall be used to develop the solder-paste shear-sensitivity factor.

4.5.5 Evaluation

Record the data and enter it in Table 12.

4.5.6 Additional information

Test equipment sources: The equipment sources described below represent those currently known to the industry. Additional source names can be added when available.

Spiral pump viscometer equipment[5]:

---

5 This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Brookfield Engineering Laboratories, Inc. 240 Cushing Street Stoughton, MA 02072 (617) 344-4310

Malcom Instruments Corp. 26226 Industrial Blvd., Hayward, CA 94545, (510) 293-0580, (510) 293-0584

Shear sensitivity factor is defined as the absolute value of the slope of a graph of the log viscosity versus log r/min.

4.6 Test 5-3X06: Solder paste viscosity – Spiral pump method (applicable to 300 Pa·s)

4.6.1 Object

This test specifies a standard procedure for determining the viscosity of solder paste applicable at 300 Pa·s.

4.6.2 Test specimen

The paste to be tested shall be stabilized at (25 ± 1) °C for a minimum of 24 h prior to testing. The paste volume shall be sufficient to fill the viscometer receptacle to about 60 % of its depth.

4.6.3 Equipment/apparatus

The equipment used shall be a spiral pump viscometer (Malcom, Brookfield Viscometer or Rheometer with spiral adaptor accessory[6], or equivalent). Set the instrument rotational speed for 10 r/min. Other equipment may be used provided the results can be empirically correlated as mutually agreed upon. Additional shear rates may be specified by the user or the supplier.

4.6.4 Procedure

4.6.4.1 Preparation

a) Open the container(s), remove any internal cover, scrape off the paste adhering to the lids or internal cover(s) and the container wall(s) and add this to the paste in the container(s).

b) Using a spatula, stir the paste gently for 1 to 2 min to homogenize it, taking care to avoid the introduction of air.

c) Transfer sufficient paste to the viscometer receptacle to fill this to about 60 % of its depth. Place the receptacle in the temperature-controlled unit on the viscometer and allow it to stabilize at (25 ± 0,25) °C for 15 min.

4.6.4.2 Test

a) Immerse the instrument sensor into the sample in accordance with the equipment manufacturer's instructions. The solder paste shall not cover the pump outlet.

b) Turn on the chart recorder and set the instrument to run at one specific shear rate. Take a reading when the output has been stable for at least 1 min.

4.6.5 Evaluation

Record the data and enter it in Table 12.

4.6.6 Additional information

Test equipment sources: The equipment sources described below represent those currently known to the industry. Users of this test method are urged to submit additional source names as they become available, so that this list can be kept as up-to-date as possible.

---

6 This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Spiral pump viscometer equipment[7]:

Brookfield Engineering Laboratories, Inc., 240 Cushing Street, Stoughton, MA 02072 (617) 344-4310;

Malcom Instruments Corp., 26226 Industrial Blvd., Hayward, CA 94545, (510) 293-0580, (510) 293-0584

4.7 Test 5-3X07: Solder paste – Slump test

4.7.1 Object

This procedure determines vertical and horizontal slump for solder pastes.

4.7.2 Test specimen

A standard specimen shall be prepared using a clean frosted glass microscope slide measuring 7,6 cm × 2,5 cm, minimum 1 mm thick. An equivalent alumina or glass epoxy substrate may be used.

4.7.3 Equipment/apparatus

a) Stencils.

b) Stencil patterns (as shown in Figures 1 and 2 of IEC 61190-1-2:2014).

c) Steel squeegee (razor blade).

d) Oven.

e) Microscope.

4.7.4 Procedure

4.7.4.1 Preparation

a) Prepare the specimen using the appropriate stencil pattern shown in Figures 1 and 2 of IEC 61190-1-2:2014. Deposit solder paste patterns on two substrates for each stencil pattern. The printed pattern shall be uniform in thickness with no solder particles outside the lands. The supplier and user should use the same printing method (see Figures 1 and 2).

b) One test specimen shall be marked as specimen #1 and one specimen as #2 and processed in accordance with item a).

---

7 This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

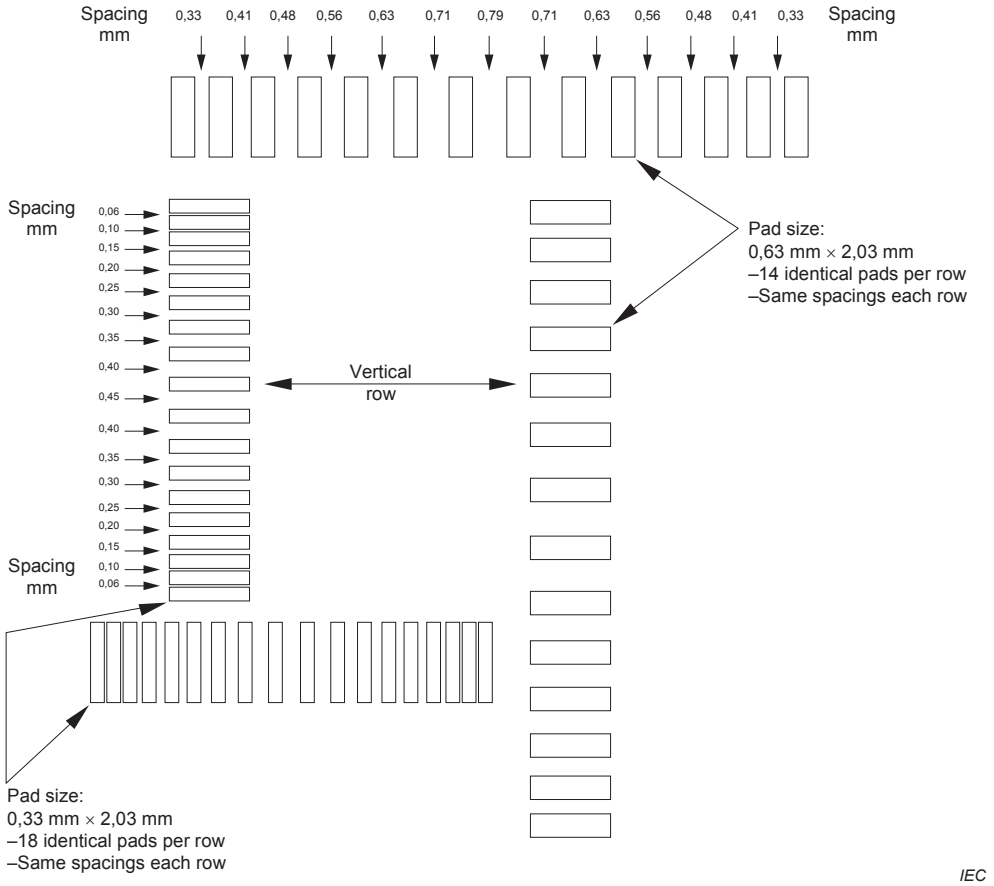


Figure 1 – Slump test stencil thickness, 0,20 mm

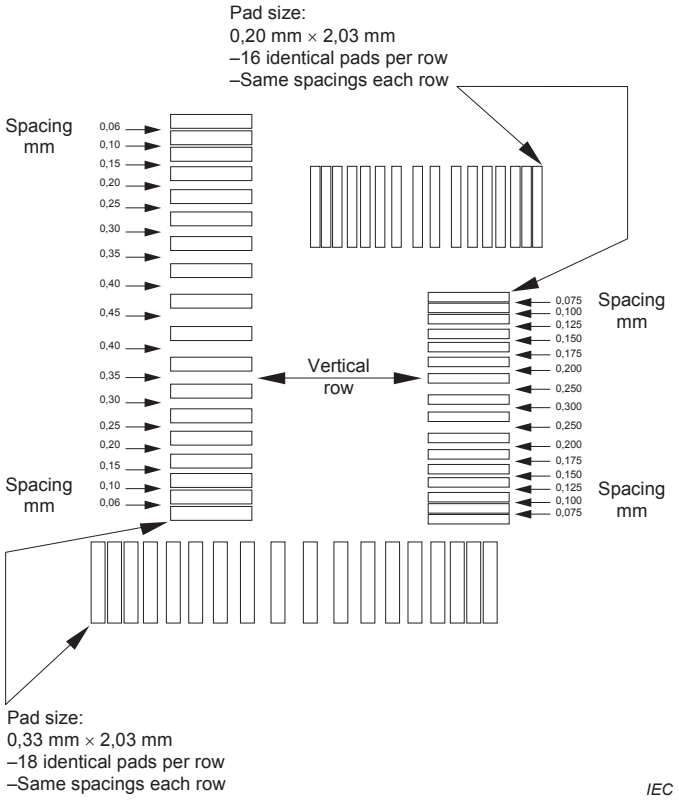


Figure 2 – Slump test stencil thickness, 0,10 mm

4.7.4.2 Test

a) The specimens shall be stored for (10 to 20) min at (25 ± 5) °C and (50 ± 10) % relative humidity and specimen #1 examined for slump.

b) Specimen #2 shall be heated to (150 ± 10) °C for 10 to 15 min, cooled to ambient and examined for slump.

4.7.5 Evaluation

Enter the spacings which have bridged with a suitable check mark in Tables 3 or 4.

Table 3 – Example of a test report – Stencil thickness, 0,2 mm

Stencil (0,2 mm thick)					
Land size 0,63 mm × 2,03 mm			**Land size 0,33 mm × 2,03 mm**		
Spacing mm	Hor.	Vert.	Spacing mm	Hor.	Vert.
0,79			0,45		
0,71			0,40		
0,63			0,35		
0,56			0,30		
0,48			0,25		
0,41			0,20		
0,33			0,15		
			0,10		
			0,08		

Table 4 – Example of a test report – Stencil thickness, 0,1 mm

Stencil (0,1 mm thick)					
Land size 0,33 mm × 2,03 mm			**Land size 0,2 mm × 2,03 mm**		
Spacing mm	Hor.	Vert.	Spacing mm	Hor.	Vert.
0,45			0,30		
0,40			0,25		
0,35			0,20		
0,30			0,175		
0,25			0,15		
0,20			0,125		
0,15			0,10		
0,10			0,075		
0,08					

4.8 Test 5-3X08: Solder paste – Solder ball test

4.8.1 Object

This test is carried out to determine the reflow properties of the solder paste. The ability of the pre-alloyed solder particles in the paste to reflow into a sphere on a non-wettable substrate is determined under defined test conditions.

4.8.2 Test specimen

The test specimen shall consist of a frosted glass microscope slide, an alumina substrate or glass/epoxy printed circuit-board with a thickness of 0,60 mm to 0,80 mm and a minimum length and width dimension of 76 mm and 25 mm, respectively.

4.8.3 Equipment/apparatus

a) Metal stencils
   - Stencil for solder paste using solder powder Type 1-4 in accordance with IEC 61190-1-2: Stencil 76 mm × 25 mm × 0,2 mm provided with at least 3 round holes of 6,5 mm diameter apertures with a minimum distance between centres of 10 mm.
   - Stencil for solder paste using solder powder Type 5-6 in accordance with IEC 61190-1-2: Stencil 76 mm × 25 mm × 0,1 mm provided with at least 3 round holes of 1,5 mm diameter apertures with a minimum distance between centres of 10 mm.

b) Spatula.

c) Solder bath not less than 100 mm × 100 mm × 75 mm containing solder suitable to maintain a temperature of 25 °C above the liquidus temperature of the solder paste being evaluated.

d) Flat hot plate.

e) Surface temperature thermometer.

f) Magnifying glass with a 10× to 20× magnification.

4.8.4 Procedure

4.8.4.1 Preparation

a) Set the temperature of the solder bath or hot plate to (25 ± 3) °C above the liquidus temperature of the solder alloy.

b) Condition the paste to a uniform temperature of (25 ± 2) °C.

c) Homogenize the solder paste by hand stirring with a spatula.

d) Prepare two test specimens with either/or both stencils listed above. The solder paste should be squeegeed with the spatula to fill and level each hole.

4.8.4.2 Test conditions

a) Test one specimen within (15 ± 5) min after placement of solder paste on test specimen.

b) Test the second specimen (4h ± 15 min) after placement of solder paste on test specimen. Storage for 4 h shall be at (25 ± 3) °C and (50 ± 10) % RH.

4.8.4.3 Conditioning heating equipment

a) Clean the surface of the solder bath with the scraper.

b) Remove all foreign material from the surface of the hot plate to ensure proper control.

4.8.4.4 Solder reflow

Reflow specimens by one of the following two methods.

a) Lower the substrate, in a horizontal position with the paste deposit on top, into the solder bath at a speed of (25 ± 2) mm/s until the substrate is 50 % submerged. It is important that good thermal contact is achieved between the molten solder and the substrate. As soon as the solder has melted, withdraw the substrate from the solder bath maintaining it in a horizontal position. The total time on the solder bath shall not exceed 20 s.

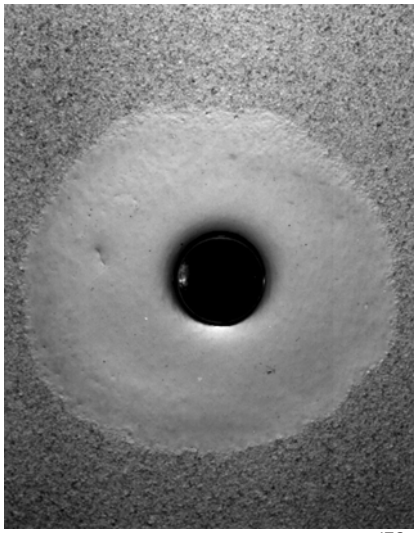
b) Place the substrate on the hot plate. As soon as the solder has melted, withdraw the substrate from the hot plate maintaining a horizontal position. The reflow shall occur within 20 s after the specimen is placed in contact with the hot plate.

4.8.5 Evaluation

a) Examine the reflowed specimens under 10× to 20× magnification.

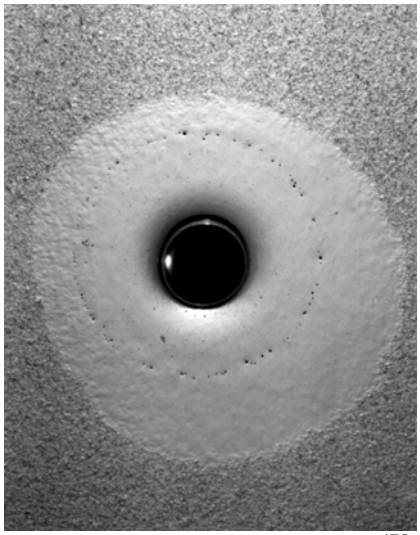
b) Solder-ball size and number should be compared with Figure 3.

c) Record the degree of reflow in comparison with Figure 3 for the 6,5 mm and 1,5 mm accept/reject conditions, respectively.



The solder paste has melted into a big single solder ball.

a) Category 1 – Preferred (pass)

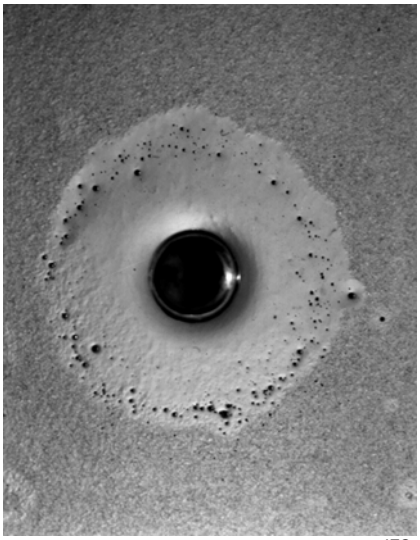


The solder paste has melted into a big solder ball, which must not be surrounded by clustered small solder balls.

b) Category 2 – Acceptable (pass)

The solder paste has melted into a big solder ball, which is surrounded by clustered solder balls.

c) Category 3 –Unacceptable clusters (reject)



The molten solder paste has not melted completely or has formed many individual solder balls.

d) Category 4 – Unacceptable (reject)

Figure 3 – Solder-ball test evaluation

When evaluating Type 1-4 powder, the solder paste shall meet the acceptance criteria presented in Figure 3. In addition, individual solder balls of greater than 75 microns shall not form on more than one of the three test patterns used in the evaluation.

When evaluating Type 5-6 powder, the solder paste shall meet the acceptance presented in Figure 3. In addition, individual solder balls of greater than 50 microns shall not form on more than one of the three test patterns used in the evaluation.

4.9 Test 5-3X09: Solder paste – Tack test

4.9.1 Object

This test method specifies two methods for determining the ability of a printed pattern of solder paste to retain a probe placed in the solder paste by measuring the force required to separate the probe from the paste. Time between printing and probe placement is progressively increased to simulate variables in a manufacturing process.

Method A applies a force of (3 ± 0,3) N to the specimen.

Method B applies a force of (0,5 ± 0,05) N to the specimen.

4.9.2 Method A

4.9.2.1 Test specimen

A representative sample of this paste should be printed out, using a stencil, onto clean plain-glass slides. At least six paste deposits shall be printed per required time data-point. The final deposits shall be circular, 6,3 mm in diameter and 0,25 mm thick. Mark the test specimen in a suitable manner to identify the specimen and the time after printing when tackiness is to be measured. The prepared specimens shall be stored at (25 ± 2) °C and (50 ± 10) % relative humidity (RH) until evaluated. The samples shall not be stored in an enclosed cabinet or container, which allows the solder paste solvent vapours to saturate the environment surrounding the printed paste, thus preventing natural drying of the material.

4.9.2.2 Equipment/apparatus

A Chatillon tackiness tester or other equipment may be used, provided it is capable of accurately measuring force when tested at a similar velocity. The equipment shall have a stainless steel test probe with a nominal (5,1 ± 0,13) mm diameter bottom surface, which is smooth, flat, and aligned parallel to the plane of the subject test specimen. The probe shall contact the test specimen at a controlled speed and apply a controlled, fixed initial contact force. Finally, a means shall be provided to withdraw the test probe from the surface of the test specimen at a controlled speed and record the peak force required to break contact with the test specimen.

4.9.2.3 Procedure

Place the specimen slide under the test probe and centre the probe over one of the three printed patterns. Bring the test probe into contact with the printed paste specimen at a rate of (2,5 ± 0,5) mm/m and apply a force of (3 ± 0,3) N to the specimen. Within 5 s following application of this force, withdraw the probe from the specimen at a rate of (2,5 ± 0,5) mm/m and record the peak force required to break the contact. Take at least five additional measurements under the same test conditions and average all the readings. Record both the tack force and time following paste printing.

4.9.2.4 Evaluation

Initial measurements shall be taken immediately after printing. Subsequent measurements of force shall be taken as needed to best define the rise and decline of the tack force. Tackiness

data should be presented in graph form, provided that the graph with tack force is plotted as a function of time after printing. The data can also be reported as follows.

a) Time to reach 80 % of the peak value.

b) The peak tack force in grams with the expected variation.

c) Time over which the peak value is maintained or for the tack force to decline to 80 % of its peak value.

Record the data and enter it in Table 12.

4.9.3 Method B

4.9.3.1 Test specimen

a) The solder paste is printed on the glass plate by using the metal mask, and five circular solder pastes of 6,5 mm in diameter and of 0,2 mm in thickness shall be made. The thickness of five printed patterns shall be uniform so that the solder particles may not be separated from these circular solder pastes.

b) The test specimen prepared as indicated above shall be kept at a temperature of (25 ± 2) °C with a relative humidity of (50 ± 10) % until the test is carried out.

4.9.3.2 Equipment/apparatus

a) Tackiness measuring device.

b) Metal mask: The metal mask shall be 0,2 mm in thickness, and have five holes of 6,5 mm in diameter.

c) Cylindrical probe made of stainless steel: The cylindrical probe shall be $(5{,}10\ ^{-5}_{+23})$ mm in diameter and mounted on the pressurizing system of the tackiness measuring device.

d) Slide glass plate (76 mm × 25 mm × 1 mm).

e) Fixing device: The fixing device shall fix the slide glass plate.

f) Solvent: The solvent shall be suitable for removing the grease of the probe and dissolve the paste flux, such as propan-2-ol.

4.9.3.3 Procedure

a) The test specimen shall be placed under the probe, and the probe is set to the centre of one of five printed patterns. The probe shall be lowered into the printed paste at the speed of 2,0 mm/s, and pressurized at the specified pressure of (0,5 ± 0,05) N. After pressurization, the probe is pulled upward out of the solder paste at the speed of 10 mm/s within 0,2 s, and the maximum load required for the separation is recorded. Five measurements shall be carried out under the same condition, and the measured values shall be averaged. Then the tackiness strength (kN/m^2) shall be calculated from these load values.

b) The relationship between the elapsed time after printing the solder paste and the tackiness strength shall be obtained with the above procedures.

4.9.3.4 Evaluation

The tackiness of the solder paste shall be evaluated by the elapsed time after printing the solder paste and the tackiness strength.

4.9.4 Test equipment sources

The equipment sources[8] described below represent those currently known to the industry. Users of this test method are urged to submit additional source names as they become available so that this list can be kept as up-to-date as possible.

AMETEK/Chatillon 8800 Somerset Drive, Largo, FL 33773, Phone; 1 (800) 527-9999

Malcom instruments Corp., 26226 industrial Blvd., Hayward, CA 94545,Phone: 1 (510) 293-0580

4.10 Test 5-3X10: Solder paste – Wetting test

4.10.1 Object

Determine the ability of a solder paste to wet an oxidized copper surface and to qualitatively examine the amount of spatter of the solder paste during reflow.

4.10.2 Test specimen

A copper-clad base material of 75 mm × 25 mm and of a thickness of 0,8 mm minimum. The cladding thickness shall be 35 μm at least.

4.10.3 Equipment/materials/apparatus

a) Flat hot plate.

b) Specimen tongs.

c) Beaker 400 cm^3.

d) Magnifying glass with 10× magnification.

e) Liquid copper cleaner.

f) Deionized water.

g) Propan-2-ol.

h) Solvent for residual flux removal.

i) Stencil measuring 76 mm × 25 mm × 0,2 mm with at least 3 round holes of 6,5 mm diameter apertures with a minimum distance between centres of 10 mm.

4.10.4 Procedure

4.10.4.1 Preparation

The specimen shall be cleaned with a liquid copper cleaner, washed thoroughly with water, rinsed with propan-2-ol, dried and then placed in boiling deionized water for 10 min and air dried.

4.10.4.2 Test

a) Place the stencil on the test specimen and print the solder paste test pattern.

b) Perform a reflow process using the procedure outlined in 4.8.4.4 of test method 5-3X08.

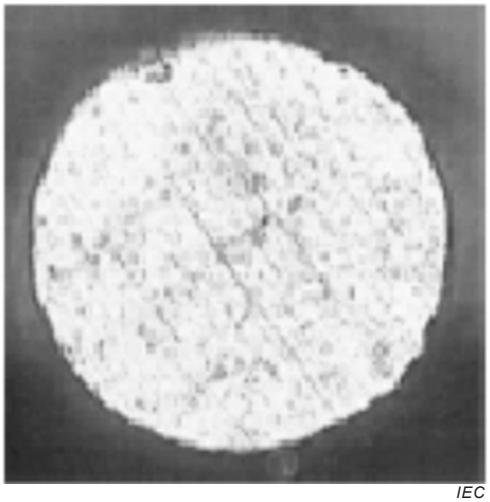
c) After reflow, the residual flux shall be removed with a suitable solvent.

---

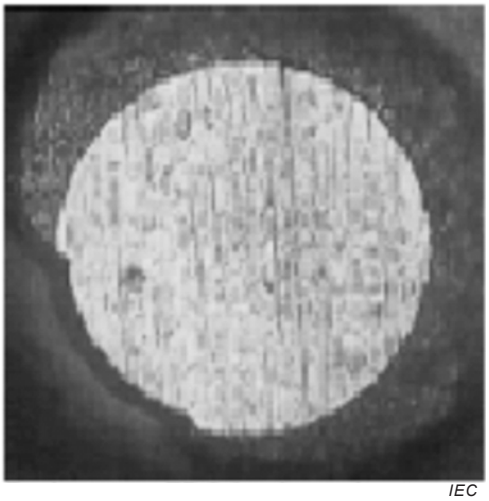
[8] This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

4.10.5 Evaluation

When examined visually at 10×, the solder shall uniformly wet the copper and there should be no evidence of dewetting or non-wetting of the copper and there shall be no solder spatter around the printed dots (see Figure 4). Record the data and enter it in Table 12.



Good solder wetting, surface bond is uniform and no excess solder



Solder wetted a part of the copper surface although some dewetting occurred

Figure 4 – Solder wetting examples

4.11 Test 5-3X11: Determination of solder powder particle size distribution – Screen method for types 1-4

4.11.1 Object

To describe a method for determining whether or not the powder in a solder paste complies with the relevant powder type.

4.11.2 Test specimen

Approximately 150 g of solder paste.

4.11.3 Equipment/apparatus

a) Vibratory test sieving machine.
b) Test sieves with mesh openings of 150 μm, 75 μm, 45 μm, 38 μm, 25 μm and 20 μm.
c) Sieve bottom receiver and lid.
d) Balance (scale) to within an accuracy of 0,01 g.
e) Beaker 400 ml to 600 ml.
f) Watch glass.
g) Solvent.
h) Acetone.
i) Spatula.

4.11.4 Procedure

4.11.4.1 Preparation

Wait, if necessary, until the solder paste is at room temperature.

4.11.4.2 Test

a) Homogenize the paste by stirring with the spatula.

b) Weigh paste containing approximately 110 g of solder alloy into the carefully cleaned beaker.

c) Add approximately 50 ml solvent.

d) Stir the mixture with the spatula so that the flux in the paste can dissolve in the solvent.

e) Cover the beaker with the watch glass.

f) Let the beaker with the watch glass stand until the solder powder settles.

g) Decant, carefully, as much as possible of the fluid without losing any of the solder powder.

h) Repeat the extraction procedure five times, using 50 ml solvent for each extraction.

i) Add approximately 50 ml acetone to the washed solder powder and stir with the spatula to assist in drying.

j) Let the solder powder settle.

k) Decant, carefully, as much as possible of the acetone.

l) Repeat the acetone wash two additional times.

m) Allow the powder to dry at room temperature until the weight is constant.

n) Weigh the test sieves with mesh opening sizes appropriate for the type of powder being tested, and weigh the sieve bottom receiver as well. Typical sieves required are shown in Table 5.

o) Place the sieves on the receiver with the sieve with the smallest opening on the receiver and process sequentially upwards to the largest opening screen.

p) Weigh the powder and put this in the top sieve.

q) Place the lid on the sieve combination and transfer this to the sieving machine.

r) Run the machine for approximately 40 min.

s) Reweigh the sieves and the receiver.

t) Subtract the original weights of the sieves and the receiver to obtain the weights of powder with sizes greater than, within, and less than the nominal size range from Table 6.

4.11.4.3 Evaluation

Express the masses of the powder above, within, and below the nominal size range as percentages of the mass of the original specimen. Enter the data in Table 7.

Table 5 – Screen opening

Powder	Screen opening	
Type 1	150 μm	75 μm
Type 2	75 μm	45 μm
Type 3	45 μm	25 μm
Type 4	38 μm	20 μm

Table 6 – Portions of particle sizes by weight % – nominal values

Powder	Less than 0,5 % larger than	80 % minimum between	10 % maximum less than
Type 1	150 μm	150 μm to 75 μm	75 μm
Type 2	75 μm	75 μm to 45 μm	45 μm
Type 3	45 μm	45 μm to 25 μm	25 μm
Type 4	38 μm	38 μm to 20 μm	20 μm

Table 7 – Powder particle size distribution record

a) **Powder**	b) **Particle size distribution %**		
Type 1	>150 μm _____%	> 75 μm _____%	< 75 μm _____%
Type 2	> 75 μm _____%	> 45 μm _____%	< 45 μm _____%
Type 3	> 45 μm _____%	> 25 μm _____%	< 25 μm _____%
Type 4	> 38 μm _____%	> 20 μm _____%	< 20 μm _____%

4.12 Test 5-3X12: Solder powder particle size distribution – Measuring microscope method

4.12.1 Object

This test specifies a standard procedure for estimating the particle size and the particle shape of solder powder in solder pastes by microscopic methods.

4.12.2 Test specimen

1 g of solder paste.

4.12.3 Equipment/apparatus

a) Thinner.
b) Spatula.
c) Beaker 30 ml.
d) Microscope, magnification 100 times.
e) Measuring ocular, scale division 10 μm.
f) Microscope slides.
g) Microscope glass cover slips.

4.12.4 Procedure

4.12.4.1 Preparation

Wait, if necessary, until the solder paste is at room temperature.

4.12.4.2 Test

a) Homogenize the paste by stirring with the spatula.

b) Weigh approximately 4 g of thinner.

c) Add approximately 1 g of the solder paste.

d) Stir with the spatula until a uniform mixture has been obtained.

e) Apply a small drop on the microscope slide.

f) Cover the slide with the cover slip and press gently to spread out the small drop between the glasses.

g) Measure with the microscope the length and width of the estimated smallest and largest solder powder particles in a viewing area of approximately 50 particles. (Photographs may be used for measuring and/or reference purposes.)

h) Estimate the principle shape of the particles as spherical or non-spherical.

4.12.4.3 Evaluation

Express the masses of the powder above, within, and below the nominal size range as percentages of the mass of the original specimen. Enter the data in Table 8.

Table 8 – Powder particle size distribution record

Powder	Particle size distribution %		
Type 1	> 150 μm _____%	> 75 μm _____%	<75 μm _____%
Type 2	> 75 μm _____%	> 45 μm _____%	< 45 μm _____%
Type 3	> 45 μm _____%	> 25 μm _____%	< 25 μm _____%
Type 4	> 38 μm _____%	> 20 μm _____%	< 20 μm _____%
Type 5	> 30 μm _____%	> 15 μm _____%	< 15 μm _____%
Type 6	> 15 μm _____%	> 5 μm _____%	< 5 μm _____%
Type 7	>11 μm _____%	>2 μm _____%	<2 μm _____%

4.13 Test 5-3X13: Solder powder particle size distribution – Optical image analyser method

4.13.1 Object

This test method is designed to determine powder particle size distribution in creams by image analysis.

4.13.2 Test specimen

10 g of solder paste.

4.13.3 Equipment/apparatus

a) Thinner.

b) Image analyser.

c) Glass rod.

d) Cover glasses.

e) Glass slides.

f) Stencil.

4.13.4 Procedure

4.13.4.1 Preparation

a) Stencil some solder cream onto a glass slide using a stencil of 0,1 mm in thickness and with an opening of 5 mm or 6 mm diameter.

b) Apply a little thinner to the solder paste and gently disperse the paste over an area about 20 mm diameter, using a glass rod. Cover with a 22 mm diameter cover glass and gently press to give a monolayer dispersion of powder particles under the cover glass.

c) It is important to get a good dispersion without a lot of bubbles or particle agglomerates. If the paste you are examining has a high metal content, remove some of the stencilled paste before dispersing it. The standard stencils are suitable for 85 % – 86 % metal paste.

d) Label the glass slide with the powder batch number.

4.13.4.2 Images for analysis

The next step is to put 10 or 15 images from each sample into an image directory and then proceed as follows.

a) Start up the image analyser.

b) Set up the microscope for appropriate illumination and select the X10 magnification.

c) Put the slide on the microscope, focus, swing the binocular eyepiece to the left sending the light to the TV camera, and refocus on the screen.

d) Ensure that there are no agglomerations or badly out-of-focus particles and then capture the image.

e) Capture 10 images covering the slide in a systematic way without consciously selecting areas (other than avoiding agglomerations and areas of very low particle density).

f) Record the number of the slide and remove from the microscope.

g) Put the next slide on the microscope and repeat the process.

h) When all the samples have been recovered, swing the eyepiece back and switch off the microscope.

i) Comments

   – do not change the illumination between samples;

   – record a series of samples at the same magnification.

4.13.4.3 Image analysis

a) When images from the required number of samples have been entered, select 'multi sample size' on the menu (or 'one sample size' for a single sample). An image in red and blue will then come up on the screen.

b) Using the left and centre buttons on the mouse, adjust the thresholds until the red areas correspond to the particles to be measured. Selecting the right hand button allows you to vary the line on the screen where the intensity plot is measured. Adjust the top threshold so that it is about halfway down the intensity minima. Press centre and right buttons on the mouse simultaneously.

c) You should now see a green rectangle on a grey image. If there is no rectangle, press the left hand button until one appears.

d) A particle is measured if the top of the particle lies within the rectangle, so the size and position of the rectangle must be adjusted so that the sides are half a particle diameter from the sides of the screen, and the base of the rectangle a whole particle diameter from the bottom of the screen. The top of the rectangle should lie along the top of the screen.

The middle button on the mouse swaps between 'moving' and 'growing' the rectangle. When the rectangle is set, press the right hand button on the mouse to proceed.

e) On the keyboard that now comes up on the screen, select the number of samples being processed.

f) On the next keyboard select the number of particles to be measured (200 for type 1-4 and 400 for type 5-6 is suggested).

4.13.4.4 Evaluation

Express the mass of powder analysed in the image analyser within the nominal size range of percentage and record the data in Table 9.

Table 9 – Powder particle size distribution record (optical analysis)

Powder	Particle size distribution %		
Type 1	> 150 μm _____%	> 75 μm _____%	<75 μm _____%
Type 2	> 75 μm _____%	> 45 μm _____%	< 45 μm _____%
> 75 μm _____%	> 45 μm _____%	> 25 μm _____%	< 25 μm _____%
Type 4	> 38 μm _____%	> 20 μm _____%	< 20 μm _____%
Type 5	> 30 μm _____%	> 15 μm _____%	< 15 μm _____%
Type 6	> 15 μm _____%	> 5 μm _____%	< 5 μm _____%
Type 7	>11 μm _____%	> 2 μm _____%	< 2 μm _____%

4.14 Test 5-3X14: Solder powder particle size distribution – Measuring laser diffraction method

4.14.1 Object

This test method is designed to determine powder particle size distribution in the solder paste by laser scanning method (see Annex A).

4.14.2 Test specimen

Approximately 100 g solder paste.

4.14.3 Equipment/apparatus

a) Laser diffraction equipment.

b) Balance.

c) Beaker (200 ml).

d) Watch glass.

e) Isopropyl alcohol.

f) Acetone.

g) Spatula.

h) Water bath.

i) Heating device.

4.14.4 Preparation

Wait, if necessary, until the solder paste is at room temperature.

4.14.5 Test procedure

a) Homogenize the paste by stirring with the spatula.

b) Weigh approximately 100 g of the solder paste in a sufficiently clean beaker.

c) Add isopropyl alcohol of approximately 150 ml.

d) Heat it to the temperature of (50 ± 5) °C.

e) Mix it by using a spatula so that the flux in the paste may be solved in the solvent.

f) Put the watch glass upon the beaker.

g) Cool down the beaker to room temperature, and leave it until the solder powder is settled.

h) Flow out the solution in the beaker as much as possible, paying attention so that no particles flow out.

i) Repeat this distilling operation by isopropyl alcohol five times.

j) Add acetone of approximately 50 ml to the powder and stir it by using a spatula.

k) Leave it until the powders are settled.

l) Flow out acetone carefully as much as possible.

m) Put the beaker on the water bath, and dry the powder completely.

n) Take the beaker out of the water bath and leave it to room temperature.

4.14.6 Test

Weigh approximately 0,15 g of powder (a spatula of powder) from the beaker and measure the powder particle size in accordance with the directions of the laser diffraction equipment.

4.14.7 Evaluation

Express the masses of the powder above, within, and below the nominal size range as percentages of the mass of the original specimen. Enter the data in Table 10.

Record the types of laser diffraction equipment and wave length of laser to within a margin of the values given in Table 10.

Table 10 – Powder particle size distribution record

Powder	Particle size distribution in %		
Type 1	>150 μm _____%	>75 μm _____%	<75 μm _____%
Type 2	>75 μm _____%	>45 μm _____%	< 45 μm _____%
Type 3	>45 μm _____%	>25 μm _____%	< 25 μm _____%
Type 4	>38 μm _____%	>20 μm _____%	< 20 μm _____%
Type 5	>30 μm _____%	>15 μm _____%	< 15 μm _____%

Powder	Particle size distribution in %		
Type 6	>15 μm _____%	>5 μm _____%	< 5 μm _____%
Type 7	>11 μm _____%	>2μm _____%	<2 μm _____%

4.15 Test 5-3X15: Determination of maximum solder powder particle size

4.15.1 Object

This test method is designed to determine the maximum (average) solder particle size in a solder paste using a fineness of grind gauge.

4.15.2 Test specimen

4.15.2.1 General

At least 100 g of uniformly mixed solder paste.

4.15.2.2 Procedure

4.15.2.3 Equipment/apparatus

o) Gauge-Hegman Type CMA 185[9], or equivalent. A hardened steel, stainless steel, or chrome-plated steel block approximately 175 mm in length, 65 mm in width and 13 mm thick.

p) The top surface of the block shall be ground smooth and flat and shall contain one or two grooves 140 mm in calibrated length and 12,5 mm wide, parallel to the longer sides of the block.

q) Each groove shall be tapered uniformly in depth lengthwise from a suitable depth (for example 50 μm to 100 μm) at 10 mm from one end to zero depth at the other with intermediate calibrations in accordance with the depth at these points.

r) Scraper: A single- or double-edged hardened steel, stainless steel, or chrome-plated steel blade 90 mm long, 38 mm wide, and 6,4 mm thick. The edge or edges on the long sides shall be straight and rounded to a radius of approximately 0,38 mm.

4.15.2.4 Test

Use a fineness of grind gauge (Hegman) Type CMA 185 or equivalent to determine the maximum and average particle size of the powder.

4.15.3 Evaluation

Acceptance of each type of powder shall be based on the specifications listed in Table 11 and the results entered in Table 12.

---

9 Gauge-Hegman Type CMA 185 is the trade name of a product supplied by Precision Gage & Tool Co. This information is given for the convenience of users of this standard and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Table 11 – Acceptance of powders by particle sizes

Powder type	1st	4th	Major
Type 1	160 μm	150 μm	140 μm
Type 2	80 μm	75 μm	65 μm
Type 3	50 μm	45 μm	40 μm
Type 4	40 μm	38 μm	35 μm
Type 5	30 μm	25 μm	23 μm
Type 6	20 μm	15 μm	15 μm
Type 7	15 μm	11 μm	11 μm

Refer to ASTM D-1210-79 (see Bibliography).

4.16 Test 5-3X16: Solder paste metal content by weight

4.16.1 Object

This procedure determines the percent metal content for solder paste.

4.16.2 Test specimen

50 g of solder paste.

4.16.3 Equipment/apparatus

a) Balance.

b) Crucible or beaker.

c) Heat source.

d) Flux solvent.

4.16.4 Procedure

4.16.4.1 Preparation

Weigh 10 g to 50 g (to the nearest 0,01 g) of solder paste into a tared vessel suitable for melting the solder paste.

4.16.4.2 Test

a) Melt the solder at approximately 25 °C above liquidus of the alloy, remove from heat and allow solder to solidify.

b) Extract residual flux from the melt with a suitable solvent, dry and weigh metal to within 0,01 g to determine the percentage of metal content.

4.16.4.3 Evaluation

The metal content of the solder paste shall be calculated as percentage by mass by the following formula:

$$C_{\text{met}} = \frac{W_2}{W_1} \times 100$$

where

C_{met} is the metal content, expressed in percentage;

W_1 is the weight of solder paste used for the test; and

W_2 is the weight of the metal, free from flux.

Enter the results in Table 12.

Table 12 – Example of a test report on solder paste

Enter appropriate information in the top portion of the report and complete the report by entering the test results or checkmarks in the appropriate spaces.

__ Inspection purpose: _____ QPL I.D. number: _____
__ Qualification: _____ Manufacturer's identification: _____
__ Quality conformance per lot: _____ Manufacturer's batch number: _____
__ Quality conformance per time: _____ Date of manufacture: _____
__ Shelf-life extension: _____ Original use-by date: _____
__ Performance: _____ Revised use-by date: _____
Date inspection completed: __ Overall results: _ Pass ___ Fail
Inspection performed by: _____ witnessed by: _____

Inspections	User's actual requirement	Test result	P/F (*)	Tested by and date
Material				
Visual				
Metal content				
Viscosity				
Solder ball				
Slump				
Alloy				
Flux				
Powder size				
% in top screen				
% in next screen				
% in bottom screen				
% in receiver bottom				
Max. powder size				
Powder shape				
Tack				
Wetting				
* P/F = PASS/FAIL; enter P if the test results are within the tolerance of the actual requirement; otherwise, enter F.				

Annex A
(informative)

Typical comparison of particle size distributions between laser diffraction method and screen method[10]

- There is an incompatibility between methods such as sieving and image analysis that measure powder size distributions directly, and methods such as laser sizing which measure powder size distributions indirectly and use algorithms to derive powder size distributions from measured data.
- Laser sizing methods are attractive because they can analyze relatively large powder samples and give very reproducible results, in contrast to image analysis which can only examine small powder samples and give poorly reproducible results.
- Laser sizing methods use algorithms to calculate particle size distributions from scattering data. The algorithms assume smooth wide particle size distributions and do not give reliable (true) powder size distributions when applied to powder size distributions with sharp (sieved) cut-offs. In addition different machines use different algorithms and give different results. Figure A.1 below discusses drawbacks of laser sizing.
- In order to give a true oversize measurement it is recommended to calibrate sizing powder size distributions against other direct sizing methods such as image analysis
- The following Figure A.1 is a graph from Malvern Instruments[11] showing different oversize measurements between sieving and laser sizing.

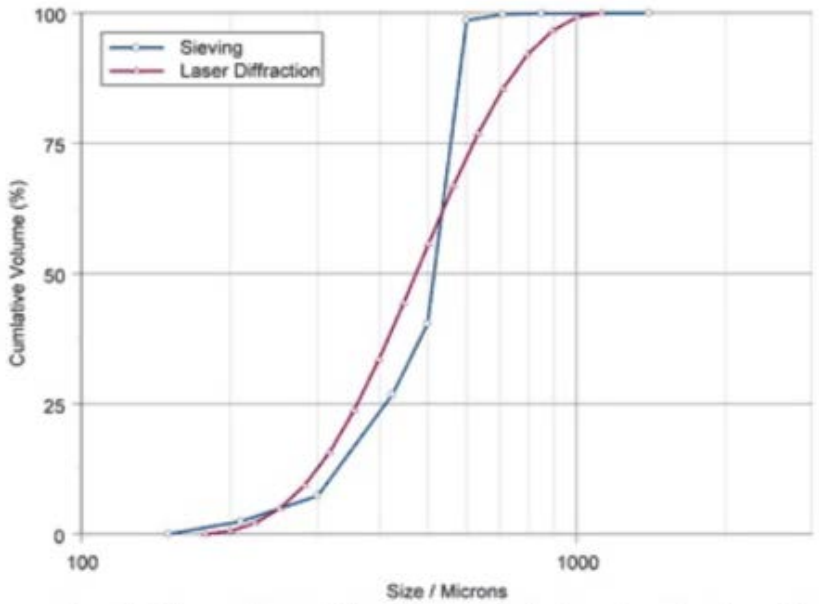


Figure A.1 – Typical comparison between laser diffraction and sieving

10 Information from the UK on particle size distributions measured by different properties

11 Reproduced with the permission of Malvern Instruments Ltd.

Bibliography

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

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

IEC 61189-1, *Test methods for electrical materials, interconnection structures and assemblies – Part 1: General test methods and methodology*

IEC 61189-2, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 2: Test methods for materials for interconnection structures*

IEC 61189-3, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 3: Test methods for interconnection structures (printed boards)*

IEC 61190-1-1, *Attachment materials for electronic assembly – Part 1-1: Requirements for soldering fluxes for high-quality interconnections in electronics assembly*

IEC 61249-2-7, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

IEC 62137:2004, *Environmental and endurance testing – Test methods for surface-mount boards of area array type packages FBGA, BGA, FLGA, LGA, SON and QFN*

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results – Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 9001, *Quality management systems – Requirements*

ISO 9455-1, *Soft soldering fluxes – Test methods – Part 1: Determination of non-volatile matter, gravimetric method*

ISO 9455-2, *Soft soldering fluxes – Test methods – Part 2: Determination of non-volatile matter, ebulliometric method*

IPC-9201:1996, *Surface Insulation Resistance Handbook*

IPC-TR-467:1996, *Supporting Data & Numerical Examples for J-STD-001B (Control of Fluxes)*

ASTM B-36 Brass Plate, Sheet, Strip, and Rolled Bar

ASTM D-1210-79 Fineness of Dispersion of Pigment-Vehicle Systems

———————

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™