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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices – Mechanical and climatic test methods – Part 20: Resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat

Dispositifs à semiconducteurs – Méthodes d'essais mécaniques et climatiques – Partie 20: Résistance des CMS à boîtier plastique à l'effet combiné de l'humidité et de la chaleur de brasage

IEC 60749-20:2020-08(en-fr)

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SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 20: Resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat

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International Standard IEC 60749-20 has been prepared by IEC technical committee 47: Semiconductor devices.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

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

a) incorporation of a technical corrigendum to IEC 60749-20:2008 (second edition);
b) inclusion of new Clause 3;
c) inclusion of explanatory notes.

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
47/2634/FDIS	47/2646/RVD

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

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

A list of all parts in the IEC 60749 series, published under the general title *Semiconductor devices – Mechanical and climatic test methods,* can be found on the IEC website.

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

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SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 20: Resistance of plastic encapsulated SMDs to the combined effect of moisture and soldering heat

1 Scope

This part of IEC 60749 provides a means of assessing the resistance to soldering heat of semiconductors packaged as plastic encapsulated surface mount devices (SMDs). This test is destructive.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60749-3, *Semiconductor devices – Mechanical and climatic test methods – Part 3: External visual examination*

IEC 60749-30, *Semiconductor devices – Mechanical and climatic test methods – Part 30: Preconditioning of non-hermetic surface mount devices prior to reliability testing*

IEC 60749-35, *Semiconductor devices – Mechanical and climatic test methods – Part 35: Acoustic microscopy for plastic encapsulated electronic components*

3 Terms and definitions

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

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

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

3.1
acoustic tomography
determination of the physical qualities of a known substance by measuring how long it takes sound to travel through it

3.2
classification reflow temperature
T_c
maximum body temperature for which the component moisture sensitivity level (MSL) is verified by the component manufacturer and as noted on the caution and/or bar code label

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3.3
crack
separation within a bulk material

Note 1 to entry: See also delamination (3.5).

3.4
dead-bug orientation
orientation of a package with the terminals facing upwards

3.5
delamination
interfacial separation between two materials intended to be bonded

Note 1 to entry: See also crack (3.3).

3.6
floor life
allowable time period after removal from a moisture barrier bag, dry storage, or dry bake and before the solder reflow process

Note 1 to entry: For the purposes of this document "'unlimited" floor life only refers to moisture/reflow related failures and does not take into consideration other failure mechanisms or shelf life issues due to long term storage.

3.7
live-bug orientation
orientation of a package when resting on its terminals

3.8
moisture sensitivity level
MSL
rating indicating a component's susceptibility to damage due to absorbed moisture when subjected to reflow soldering

3.9
soak
exposure of a component for a specified time at a specified temperature and humidity

4 General description

Package cracking and electrical failure in plastic encapsulated SMDs can result when soldering heat raises the vapour pressure of moisture which has been absorbed into SMDs during storage. These problems are assessed. In this test method, SMDs are evaluated for heat resistance after being soaked in an environment which simulates moisture being absorbed while under storage in a warehouse or dry pack. Moisture sensitivity level (MSL) ratings generated by this document are utilized to determine the soak conditions for preconditioning in accordance with IEC 60749-30.

5 Test apparatus and materials

5.1 Humidity chamber

The humidity chamber shall provide an environment complying with the temperature and relative humidity defined in 6.3.

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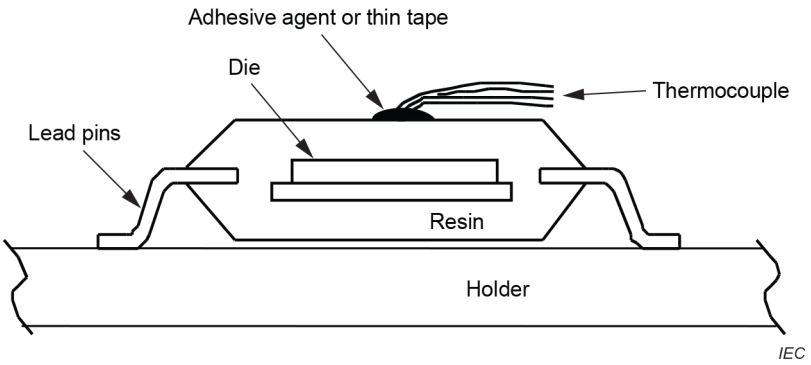
5.2 Reflow soldering apparatus

The infrared convection, the convection and the vapour-phase reflow soldering apparatus shall provide temperature profiles complying with the conditions of soldering heat defined in 6.4.2 and 6.4.3. The settings of the reflow soldering apparatus shall be adjusted by temperature profiling of the top surface of the specimen while it is undergoing the soldering heat process, measured as shown in Figure 1.



The adhesive agent or thin tape should have good thermal conductivity.

Figure 1 – Method of measuring the temperature profile of a specimen

5.3 Holder

Unless otherwise detailed in the relevant specification, any board material, such as epoxy fibreglass or polyimide, may be used for the holder. The specimen shall be placed on the holder by the usual means and in a position as shown in Figure 1. If the position of the specimen, as shown in Figure 1, necessitates changing the shape of terminations and results in subsequent electrical measurement anomalies, a position that avoids changing the shape of terminations may be chosen, and this shall be specified in the relevant specification.

5.4 Wave-soldering apparatus

The wave-soldering apparatus shall comply with conditions given in 6.4.4. Molten solder shall usually be flowed.

5.5 Solvent for vapour-phase reflow soldering

Perfluorocarbon (perfluoroisobutylene) shall be used.

5.6 Flux

Unless otherwise detailed in the relevant specification, the flux shall consist of 25 % by weight of colophony in 75 % by weight of isopropyl alcohol, both as specified in Annex B of IEC 60068-2-20:2008.

5.7 Solder

A solder of the composition as specified in Table 1 of IEC 60068-2-20:2008 shall be used.

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6 Procedure

6.1 Initial measurements

6.1.1 Visual inspection

Visual inspection, as specified in IEC 60749-3, shall be performed before the test. Special attention shall be paid to external cracks and swelling, which will be looked for under a magnification of 40X.

6.1.2 Electrical measurement

Electrical testing shall be performed as required by the relevant specification.

6.1.3 Internal inspection by acoustic tomography

Unless otherwise detailed in the relevant specification, internal cracks and delamination in the specimen shall be inspected by acoustic tomography in accordance with IEC 60749-35.

6.2 Drying

Unless otherwise detailed in the relevant specification, the specimen shall be baked at 125 °C ± 5 °C for at least 24 h.

NOTE 1 This time/temperature is modified if desorption data on the particular device under test shows that a different condition is required to obtain a "dry" package when starting in the wet condition for 85 °C/85 % RH.

NOTE 2 If a bake test is interrupted for more than 15 min, then the total time of the interruption is excluded from the bake time. The interruption time is taken into account (if no greater than 1 h) then re-incorporated to ensure a minimum of 24 h. For instance, if the interruption was 45 min, then the total bake test time would be 24 h and 45 min. If greater than 1 h the bake is restarted for a full 24 h.

6.3 Moisture soak

6.3.1 General

Unless otherwise detailed in the relevant specification, moisture soak conditions shall be selected on the basis of the packing method of the specimen (see A.1.1, Annex A). If baking the specimen before soldering is detailed in the relevant specification, the specimen shall be baked instead of being subjected to moisture soak.

6.3.2 Conditions for non-dry-packed SMDs

The moisture soak condition shall be selected from Table 1, in accordance with the permissible limit of actual storage (see A.1.2.1).

Table 1 – Moisture soak conditions for non-dry-packed SMDs

Condition	Temperature °C	Relative humidity %	Duration time h	Permissible limit on actual storage
A1 or B1	85 ± 2	85 ± 5	168 ± 24	< 30 °C, 85 % RH
RH: relative humidity NOTE Conditions A1 and B1 indicate moisture soak for non-dry-packed SMDs under either method A or B.				

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6.3.3 Moisture soak for dry-packed SMDs

6.3.3.1 General

Moisture soak conditions for dry-packed SMDs may be used as specified in method A, Table 2, or method B, Table 3. Moisture soak conditioning for dry-packed SMDs consists of two stages. The first stage of conditioning is intended to simulate moisturizing SMDs before opening the dry pack/dry cabinet. The second stage of conditioning is to simulate moisturizing SMDs during storage after opening the dry pack for soldering (floor life). Moisture soak conditioning for dry-packed SMDs shall be selected from method A or B. Method A shall be used when the relative humidity in the dry pack or dry cabinet is specified by the manufacturer as being between 10 % and 30 %. Method B shall be used when the relative humidity in the dry pack or dry cabinet is specified by the manufacturer as being below 10 %.

6.3.3.2 Method A

Unless otherwise detailed in the relevant specification, the first stage conditioning of A2, as shown in Table 2, shall be performed. Subsequently, the second stage conditioning of A2, as shown in Table 2, shall be performed within 4 h of finishing the first stage of conditioning (see A.1.2.2).

The relative humidity of the first stage conditioning shall be the same as the upper limit of the relative humidity inside the moisture barrier bag. The relative humidity of the second stage conditioning shall be the same as the conditions of floor life.

Where required in the relevant specification, test conditions other than those of the moisture barrier bag and floor life conditions may be specified in the moisture soak conditions of Table 2.

Table 2 – Moisture soak conditions for dry-packed SMDs (method A)

Condition	Moisture soak conditions	Permissible storage conditions in the dry pack and the dry cabinet	Condition of floor life
A2 first-stage conditioning	(85 ± 2) °C, (30 ± 5) % RH, 168^{24}_{-0} h	< 30 °C, 30 % RH, 1 year	–
A2 second-stage conditioning	(30 ± 2) °C, (70 ± 5) % RH, 168^{24}_{-0} h	–	< 30 °C, 70 % RH, 168 h
RH: Relative humidity			

NOTE 1 The first stage of conditioning represents storage conditions in the dry pack and the dry cabinet, as well as increasing relative humidity in the dry pack, by repacking the SMDs at the distributor's facility and the user's inspection facility. When condition A2 is applied, the SMDs are packed into a moisture-proof bag with IC trays and desiccants within a few weeks of drying. They can then be subjected to multiple temporary openings of the moisture-proof bag (for several hours at a time). Repack and inspection of SMDs are possible while the humidity indicator in the dry pack indicates less than 30 % RH since SMDs will recover the initial condition of absorbed moisture within a few days of repacking. In this case, the moisture content measurement of SMDs (see Clause A.2) is not needed as a moisture control of the dry pack. A check of the moisture indicator is sufficient for moisture control.

NOTE 2 When moisture soak of the first-stage conditioning does not result in saturation, the soak time is extended to 336 h, because SMDs in a dry pack or dry cabinet will become saturated with moisture during long-term storage. When moisture soak of the first stage of conditioning reaches saturation, the soak time is shortened.

6.3.3.3 Method B

The condition of moisture soak conditioning shall be selected from Table 3 in accordance with the condition of the floor life detailed in the relevant specification (see A.1.2.3).

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Table 3 – Moisture soak conditions for dry-packed SMDs (method B)

Condition	Moisture soak conditions	Total conditions from baking to dry packing and temporary opening of the dry pack	Condition of floor life
B2	(85 ± 2) °C, (60 ± 5) % RH, 168^{+24}_{-24} h	< 30 °C, 60 % RH, 24 h	< 30 °C, 60 % RH, 1 year
B2a	(30 ± 2) °C, (60 ± 5) % RH, 696^{+24}_{-24} h	< 30 °C, 60 % RH, 24 h	< 30 °C, 60 % RH, 4 weeks
B3	(30 ± 2) °C, (60 ± 5) % RH, 192^{+24}_{-0} h	< 30 °C, 60 % RH, 24 h	< 30 °C, 60 % RH, 168 h
B4	(30 ± 2) °C, (60 ± 5) % RH, 96^{+24}_{-0} h	< 30 °C, 60 % RH, 24 h	< 30 °C, 60 % RH, 72 h
B5	(30 ± 2) °C, (60 ± 5) % RH, 72^{+24}_{-0} h	< 30 °C, 60 % RH, 24 h	< 30 °C, 60 % RH, 48 h
B5a	(30 ± 2) °C, (60 ± 5) % RH, 48^{+24}_{-0} h	< 30 °C, 60 % RH, 24 h	< 30 °C, 60 % RH, 24 h
B6	(30 ± 2) °C, (60 ± 5) % RH, 6^{+24}_{-0} h		< 30 °C, 60 % RH, 6 h
RH: relative humidity			

NOTE Moisture soak conditions from B2 to B6 consist of the first-stage conditioning (30 °C, 60 % RH, 24 h) and the second-stage conditioning (floor life).

Contents in the dry pack of SMDs, IC trays and other materials, should be fully dried just before packing into the moisture-proof bag and the desiccant should be completely dry. This is because moist materials and degraded desiccants give off water vapour, causing the relative humidity in the dry pack to exceed 10 %. The relative humidity in the dry pack should be verified by the humidity indicator and the moisture content measurement of the SMDs, as shown in Clause A.2.

Storage of SMDs in a dry cabinet instead of a dry pack is not recommended because very low relative humidity cannot be obtained in a dry cabinet.

The individual conditions of method B should cover total storage condition from baking the SMDs to soldering them, and this should include the duration time of room storage from baking the SMDs to packing them into the dry pack, temporary opening of the dry pack and the floor life.

6.4 Soldering heat

6.4.1 General

Unless otherwise detailed in the relevant specification, the specimen shall be subjected to soldering heat within 4 h of finishing the moisture soak or baking. The method and condition of soldering heat shall be selected from 6.4.2 to 6.4.4 according to the relevant specification. Whichever method is chosen, the soldering heat cycles shall be a minimum of one and a maximum of three. Unless otherwise detailed in the relevant specification, one cycle of soldering heat shall be used. If more than one cycle is selected, the specimen shall be cooled down to below 50 °C before the second, and subsequent, soldering heat.

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NOTE If the specimen is not affected by moisture soak and drying, which takes place during room storage of over 4 h, a storage time exceeding 4 h following the completion of moisture soak or the baking can be detailed in the relevant specification.

6.4.2 Method of heating by infrared convection or convection reflow soldering

6.4.2.1 Preparation

The specimen shall be put on the holder.

6.4.2.2 Preheating

Unless otherwise specified in the relevant specification, the specimen shall be preheated at a temperature conditions range shown in A.3.1 for 60 s to 120 s in the reflow soldering apparatus.

6.4.2.3 Solder heating

Following preheating, the temperature of the specimen shall be raised to peak temperature and then lowered to room temperature. The heating condition shall be selected from Table 4 or Table 5 in accordance with the relevant specification depending on the actual soldering conditions. Tolerances of temperature and time are shown in A.3.1.

NOTE 1 In Table 4 and Table 5, the conditions of method A are applied for actual soldering on condition of short temperature profile, and the conditions of method B are applied for actual soldering on condition of long temperature profile.

NOTE 2 Following preheating, the temperature of the specimen will follow the values as indicated in the profile given in Figure A.9, Figure A.10 or Table A.2.

NOTE 3 Package ‘‘volume’’ excludes external terminals (e.g., balls, bumps, lands, leads) and/or non-integral heat sinks. Package volume includes the external dimensions of the package body, regardless of whether it has a cavity or is a passive package style.

NOTE 4 At the discretion of the device manufacturer, but not the board assembler/user, the maximum peak package body temperature (T_p) can exceed the values specified in Table 4 or Table 5. The use of a higher T_p does not change the classification temperature (T_c).

NOTE 5 The maximum component temperature reached during reflow depends on package thickness and volume. The use of convection reflow processes reduces the thermal gradients between packages. However, thermal gradients due to differences in thermal mass of SMD packages can still exist.

NOTE 6 Moisture sensitivity levels of components intended for use in a Pb-free assembly process are evaluated using the Pb-free classification temperatures and profiles defined in Table 4 and Table 5, whether or not the process is Pb-free.

Table 4 – SnPb eutectic process – Classification reflow temperatures (T_c)

Package thickness mm	Method	Time within 5 °C of specified classification temperature s	Temperature for volume mm³		
			< 350 °C	350 to 2 000 °C	< 2 000 °C
< 2,5	Method A	10	240	240	225
	Method B	20	240	225	225
≥ 2,5	Method A	10	240	240	225
	Method B	20	225	225	225

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Table 5 – Pb-free process – Classification reflow temperatures (T_c)

Package thickness mm	Method	Time within 5 °C of specified classification temperature s	Temperature for volume mm³		
			<350 °C	350 to 2 000 °C	> 2 000 °C
< 1,6	Method A	10	260	260	260
		20			
	Method B	30			
1,6 to 2,5	Method A	10	260	250	245
		20			
	Method B	30			
> 2,5	Method A	10	250	245	245
		20			
	Method B	30			

6.4.3 Method of heating by vapour-phase reflow soldering

6.4.3.1 Preparation

The specimen shall be put on the holder.

6.4.3.2 Preheating

Unless otherwise specified in the relevant specification, the specimen shall be preheated at a temperature from 100 °C to 160 °C for 1 min to 2 min in the vapour-phase soldering apparatus.

6.4.3.3 Solder heating

The temperature of the specimen shall be raised after preheating. When the temperature of the specimen has reached 215 °C ± 5 °C, it shall be maintained for 40 s ± 4 s as shown in Table 6 (refer to A.3.2).

Table 6 – Heating condition for vapour-phase soldering

Condition	Temperature °C	Time s
II-A	215 ± 5	40 ± 4

6.4.4 Method of heating by wave-soldering

6.4.4.1 Preparation

The bottom surface of the specimen shall be fixed to the holder by an adhesive agent specified in the relevant specification. Unless otherwise detailed in the relevant specification, flux shall not be applied to the specimen and holder.

If flux is applied, vaporization of solvent in the flux could affect the temperature rise of the specimen. Flux should not, therefore, be applied to the body of the specimen and should only be applied to lead pins as sparingly as possible.

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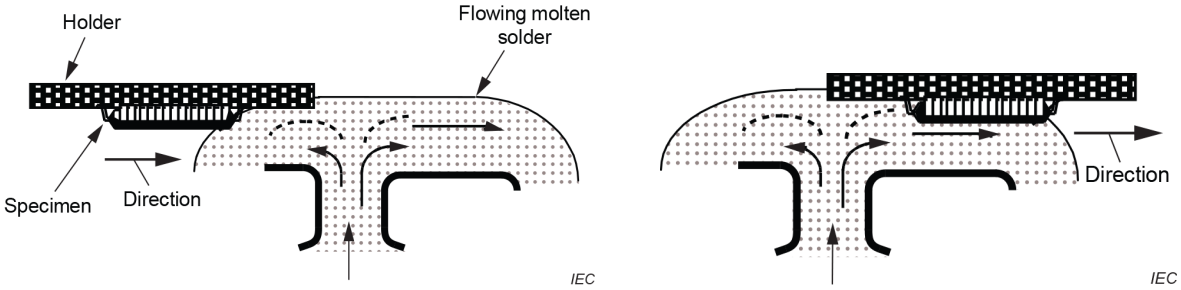
Where SMDs have a stand-off (height between the bottom of the SMD body and the bottom of the lead pin) of less than 0,5 mm (except lower thermal resistance SMDs with a heat sink and whose body thickness exceeds 2,0 mm), they should be tested by the soldering heat of methods A and B. SMDs whose body thickness exceeds 3,0 mm are tested by soldering heat by condition B. Wave-soldering of conditions III-A and III-B should be omitted because methods A and B are more severe than conditions III-A and III-B for these SMDs (refer to A.3.3).

6.4.4.2 Preheating

Unless otherwise detailed in the relevant specification, the specimen shall be preheated at a temperature of 80 °C to 140 °C for 30 s to 60 s in the soldering apparatus.

6.4.4.3 Solder heating

Following preheating, the specimen and the holder shall be immersed into flowing molten solder, as shown in Figure 2. The immersion condition shall be selected from Table 7.



a) Start of immersion

b) End of immersion

Figure 2 – Heating by wave-soldering

Table 7 – Immersion conditions for wave-soldering

Condition	Temperature of solder °C	Immersing time s	Actual soldering method
III-A	260 ± 5	5 ± 1	Single-wave
III-B	260 ± 5	10 ± 1	Double-wave

6.4.4.4 Cleaning

If the flux is applied, it shall be removed by a cleaning method detailed in the relevant specification.

6.5 Recovery

If recovery is detailed in the relevant specification, the specimen shall be stored under standard atmospheric conditions for the time given in the specification.

Wave-soldering is not commonly available to the semiconductor manufacturer. Where the manufacturer does not have access to such equipment, the method should be specified only by agreement between the manufacturer and the customer.

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6.6 Final measurements

6.6.1 Visual inspection

Visual inspection, as specified in IEC 60749-3, shall be performed after the test. Special attention shall be paid to external cracks and swelling which will be looked for under a magnification of 40X.

6.6.2 Electrical measurement

Electrical testing shall be performed as required by the relevant specification.

NOTE Lead oxidation or other mechanisms caused by baking can affect the electrical testing of the devices.

6.6.3 Internal inspection by acoustic tomography

Unless otherwise specified in the relevant specification, internal cracks and delamination in the specimen shall be inspected by acoustic tomography in accordance with IEC 60749-35.

7 Information to be given in the relevant specification

		Clause/subclause
a)	Material of holder	5.3
b)	Position of specimen on the holder	5.3
c)	Composition of flux	5.6
d)	Number of test specimens	6
e)	Item and failure criteria for initial measurement	6.1
f)	Preconditioning	6.2
g)	Method of moisture soak	6.3
h)	Conditions of drying	6.2
i)	Baking conditions instead of the moisture soak	6.3
j)	Method of moisture soak for dry packed SMDs	6.3.3
k)	Period between the stages of moisture soak conditioning	6.3.3.2
l)	Conditions of first-stage and second-stage conditioning and whether another condition is needed	6.3.3.2
m)	Soak time of the first-stage conditioning if 168 h of soak time is insufficient	6.3.3.2
n)	Moisture soak conditions for SMDs stored in completely dried dry pack	6.3.3.3
o)	Moisture soak conditions for non-dry-packed SMDs	6.3.2
p)	Period between finish of moisture soak and soldering heat	6.4.1
q)	Method and condition of soldering heat	6.4.1
r)	Number of cycles of soldering heat	6.4.1
s)	Preheat conditions for infrared convection and convection reflow soldering	6.4.2.2
t)	Heating conditions for infrared convection and convection reflow soldering	6.4.3.3
u)	Preheat conditions for vapour-phase reflow soldering	6.4.3.2
v)	Adhesion method	6.4.4.1
w)	Preheat conditions for wave-soldering	6.4.4.2

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		Clause/subclause
x)	Cleaning method for flux	6.4.4.4
y)	Recovery conditions	6.5
z)	Item and failure criteria for final measurement	6.6

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