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IPC-TM-650 TEST METHODS MANUAL

1 Scope and Purpose

1.1 Scope This method **shall** be used to simulate exposure to the thermal conditions by convection reflow assembly.

1.2 Purpose This method **shall** be used to replicate the thermodynamic effects by assembly on the test specimen. The use of this method is intended to simulate those effects that are the result of soldering thermal excursions.

1.2.1 This method **shall** be used for qualification testing of an applicable test specimen. The evaluation of acceptability for qualification **shall** be in accordance with the requirements defined in 5.3.

1.2.2 This method may be used for lot acceptance. The evaluation for lot acceptability should be in accordance with the requirements defined in 5.3 or as agreed upon between user and supplier (AABUS).

2 Applicable Documents

IPC-T-50 Terms and Definitions

IPC-2221 Generic Standard on Printed Board Design

IPC-A-600 Acceptability of Printed Boards

IPC-1601 Printed Board Handling and Storage Guidelines

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-6013 Qualification and Performance Specification for Flexible Printed Boards

IPC-6018 Qualification and Performance Specification for High Frequency (Microwave) Printed Boards

IPC-9241 Guidelines for Microsection Preparation

IPC-9631 User's Guide for IPC-TM-650, Method 2.6.27

IPC-TM-650 Test Methods Manual¹

2.1.1 Microsectioning – Microsectioning, Manual and Semi or Automatic Method

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Originating Task Group Thermal Stress Test Methodology Subcommittee (D-32)	

3 Test Specimen

3.1 Design/Construction Criteria

3.1.1 The test specimen **shall** be the A/B, AB-R, and/or the D coupon in accordance with the requirements of IPC-2221 Appendix A, or additional coupons AABUS.

3.1.2 The test specimen(s) **shall** be constructed with holes contained in the printed board it represents as follows:

- A/B, A/B-R and D coupons **shall** be constructed with both the largest plated through-holes (PTHs) and the smallest vias.
- B/R and D coupons **shall** be constructed with the intended via structure. (Multiple B/R and D coupons are used for designs with multiple structures.)

3.1.2.1 The test specimen **shall** contain the representative ground and power planes of the printed board design.

3.1.2.2 The test specimen **shall** contain the representative/applicable blind and/or buried vias of the printed board design.

3.1.3 The test specimen **shall** allow for microsection evaluation of all the applicable, representative PTHs and vias defined in 3.1.2 after exposure to the conditions of this Test Method.

3.1.4 Deviations to the test specimen design/construction or use of an alternate test specimen such as the printed board or a section of the printed board **shall** be AABUS.

4 Apparatus

4.1 Drying Oven

4.1.1 The oven **shall** be capable of maintaining a uniform set temperature within the 105 to 125 °C [221 to 257 °F] range.

4.2 Convection Reflow Oven or Simulator

4.2.1 The system used to simulate the thermodynamic effects of assembly **shall** be convection reflow.

1. Current and revised IPC Test Methods are available on the IPC Web site (www.ipc.org/html/testmethods.htm)

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4.2.1.1 The system **shall** have adequate environmental controls to maintain the tolerance range and limits in accordance with the reflow profile depicted in either Figure 5-1 or Figure 5-2.

4.2.1.2 The system should accommodate verifiable calibration compliance and reflow profile generation. See note 6.1 for additional considerations.

4.2.1.3 The test specimen **shall** be handled and stored in a controlled environment to minimize moisture ingress. See IPC-1601 for details on the proper handling and storage of test specimens.

4.2.2 Deviations to the equipment requirements and acceptability of the alternative methods **shall** be AABUS.

4.3 Microscope

4.3.1 The magnification used for defect recognition must be in agreement with the inspection requirements/capabilities defined in the applicable performance specification (e.g., IPC-6012, IPC-6013, IPC-6018, etc.) and IPC-A-600.

4.4 Resistance Measurements of IPC-2221 Appendix A, D Coupons

4.4.1 When specified by performance specification or procurement documentation, resistance measurements of the IPC-2221B Appendix A, D coupons **shall** be required.

4.4.2 The resistance measurement **shall** have enough precision to clearly determine the resistance percent change as required by the user for the resistance level of each sample's nets.

4.4.3 The total system uncertainty from resistance, temperature and time/cycle variations **shall** be less than 10% of the failure criteria required by the user. For example, if the required failure criteria is 5% then the total system uncertainty **shall** be no greater than 0.50%.

4.4.4 The resistance data **shall** consist of at least 1 reading per sample net every second during the entire reflow cycle.

5 Procedure

5.1 Conditioning

5.1.1 The test specimen **shall** be conditioned by drying in an oven to remove moisture for a minimum of six (6) hours at 105 to 125 °C [221 to 257 °F]. This conditioning process is mandatory if this method is used for qualification purposes.

This method **shall** replicate the assembly process. The requirement for conditioning (bake/drying) **shall** be in accordance with product/process lot acceptance criteria. If conditioning of the printed board is not part of the normal assembly process, and this method is being used for acceptance testing, then conditioning is not a requirement.

5.1.2 Test specimens that are thicker or more complex may require longer baking times to achieve acceptable moisture levels. Record the bake times and temperature if different than those stated in 5.1.1. See IPC-1601 for additional guidance on baking to achieve acceptable moisture levels. See note 6.2.

5.1.3 Deviations to the conditioning requirements in 5.1.1 such as when used for acceptance criteria and/or any changes to the time and temperature **shall** be AABUS. See 6.3.

5.2 Reflow Profile

5.2.1 Reflow the test specimen in accordance with Table 5-1 (default) or Table 5-2 (low temperature profile).

5.2.2 The reflow profile **shall** be in accordance with either Figure 5-1 or Figure 5-2. Figure 5-1 represents the default reflow profile. Figure 5-2 represents the low temperature profile. The times to t1, t2 and t3 may vary based on the mass of the sample test specimen. To avoid over stressing of samples, times should be shortened for low mass samples. Times should be extended for high mass samples, such that the zone (air) temperature **shall not** be more than 25 °C above the target surface temperature at any point in the cycle.

The attachment of thermocouples to the sample test specimen **shall** be such that the reflow profile is calibrated to the surface temperature of the test specimen.

5.2.3 The test specimen **shall** be subjected to a minimum of six (6) reflow cycles.

5.2.4 The cool down rate **shall** be in accordance with Table 5-1. The cool down is complete when the test specimen reaches 30 °C. The test specimen **shall** achieve a thermal equilibrium of 30 °C or less prior to starting the next reflow cycle. If the time it takes to achieve thermal equilibrium cannot be determined, then a five (5) minute dwell between reflow cycles **shall** be required.

5.2.5 Deviations to the reflow profile or number of cycles **shall** be AABUS.

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Table 5-1 260 °C Reflow Profile Specifications (Default)*

Value	Time (Seconds)	Temperature (°C)	Description
t1	210 ± 15	–	Target preheat time
t2	270 ± 10	–	Target peak reflow time
t3	330 ± 15	–	Target cool-down start time
t3 - t1	120 ± 30		Target time above T1
T1	–	230	Maximum preheat temperature
T2	–	260 ± 5	Target reflow temperature
Point	Time (Seconds)	Temperature (°C)	Description
A	0	30	Upper specification limit values
B	100	230	
C	195	230	
D	255	265	
E	285	265	
F	345	230	
G	550	30	
H	30	30	Lower specification limit values
I	157	93	
J	225	230	
K	260	255	
L	280	255	
M	315	230	
N	383	30	
Segment	Slope (°C / second)		Description
A-B & I-J	2.0		Maximum preheat rate
H-I	0.5		Minimum preheat rate
F-G	-1.0		Minimum cool-down rate
M-N	-3.0		Maximum cool-down rate

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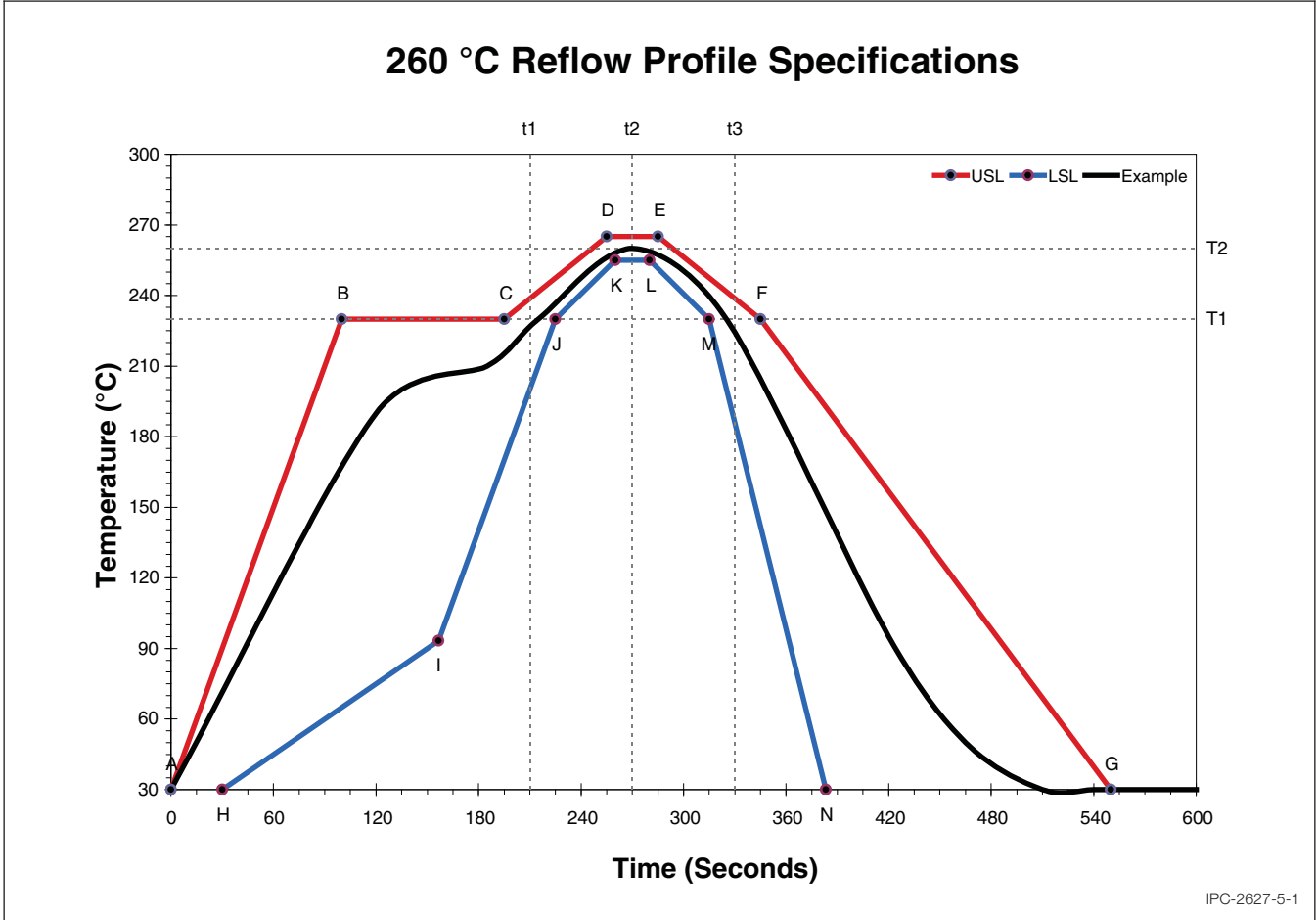


Figure 5-1 260 °C Reflow Profile Chart (Default)*

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Table 5-2 230 °C Reflow Profile Specifications (Low Temperature Profile)*

Value	Time (Seconds)	Temperature (°C)	Description
t1	186 ± 15	–	Target preheat time
t2	239 ± 10	–	Target peak reflow time
t3	292 ± 15	–	Target cool-down start time
t3 - t1	106 ± 30		Target time above T1
T1	–	203	Maximum preheat temperature
T2	–	230 ± 5	Target reflow temperature
Point	Time (Seconds)	Temperature (°C)	Description
A	0	30	Upper specification limit values
B	88	203	
C	172	203	
D	226	235	
E	252	235	
F	305	203	
G	487	30	
H	30	30	Lower specification limit values
I	139	83	
J	199	203	
K	230	225	
L	248	225	
M	279	203	
N	339	30	
Segment	Slope (°C / second)		Description
A-B & I-J	2.0		Maximum preheat rate
H-I	0.5		Minimum preheat rate
F-G	-1.0		Minimum cool-down rate
M-N	-3.0		Maximum cool-down rate

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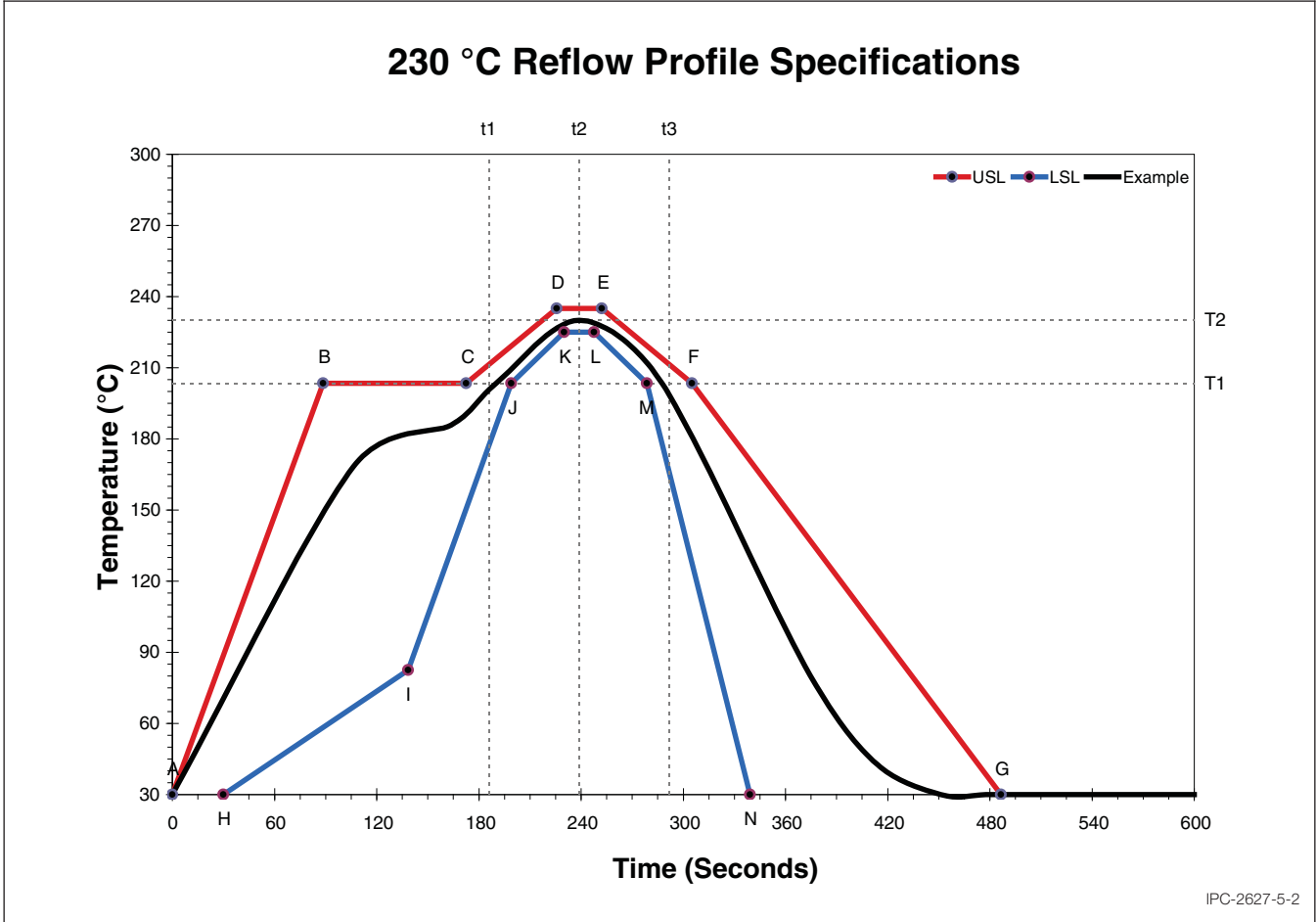


Figure 5-2 230 °C Reflow Profile Chart (Low Temperature Profile)*

* The times to t1, t2 and t3 may vary based on the mass of the sample test specimen.

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5.3 Evaluation

5.3.1 Microsection After the test specimen has been conditioned and reflowed in accordance with the requirements of 5.1 and 5.2, microsection the test specimen for compliance to the applicable performance specification.

5.3.2 Resistance Change Resistance change **shall** be used to evaluate IPC-2221 (latest revision) Appendix A D-coupons for performance based evaluation of the samples when specified.

5.3.2.1 Percent change in resistances of each sample's nets **shall** be determined using the first cycle's peak temperature resistance as the reference.

5.3.2.2 The maximum allowable percent change in resistance after the test specimen has been conditioned and reflowed in accordance with 5.1 and 5.2 **shall** be 5% maximum unless otherwise specified.

5.3.2.3 Cycles to failure, corresponding percent change of the failure, and the percent change of the final cycle **shall** be documented.

5.3.3 Deviations to the stated requirements or additional requirements defined here **shall** be AABUS.

6 Notes

6.1 The design of the convection reflow system should be flexible enough to facilitate the creation of the reflow profiles depicted in Figure 5-1 and Figure 5-2 for all the applicable test specimen designs encountered. Some issues to consider are as follows:

- Thermal mass compensation capability (energy vs. time)
- Environmental control capability (heating and cooling)
- Reproducibility of parameters
- Preheat
- Conveyor speed (if applicable)
- Heating ramp rate
- Cool down rate
- Programming capability
- Profile memory

The IPC-TM-650 website provides a non-comprehensive listing of providers of convection reflow systems suitable for meeting the reflow profiles within this test method.

6.2 Deviations to the time and temperature specified in 5.1.1 should take into consideration maintaining the solderability of the surface finish being utilized.

6.3 As this method addresses assembly issues with printed boards, it is recommended that the user of the printed board establish a drawing note in the procurement documentation to provide the printed board fabricators with guidance relative to the intended reflow process of the printed board. An example of such a drawing note is provided as follows:

Default:

"TEST COUPONS SHALL BE SUBJECTED TO REFLOW SIMULATION IAW IPC-TM-650, METHOD 2.6.27 USING THE 230 °C PROFILE (TABLE 5-2)."

Other:

"TEST COUPONS SHALL BE SUBJECTED X TIMES TO IPC-TM-650, METHOD 2.6.27 REFLOW PROFILES PER TABLE 5-Y AFTER PRECONDITIONING FOR XX HOURS AT Z °C."

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