



**Verizon NEBS™ Compliance: Qualification
Requirements for Printed Board Assemblies
Manufactured with Lead-Free Solder
for use in Telecommunications Equipment**

Verizon Technical Purchasing Requirements
VZ.TPR.9307
Issue 3, January 2010





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1.0 PURPOSE

The purpose of this Verizon Technical Purchasing Requirement (VZTPR) document is to specify the Qualification Requirements for Printed Board Assemblies (PBAs) manufactured with ‘lead-free’ solders that are intended for use in Telecommunications Equipment purchased by Verizon. The goal is to help assure the PBAs will meet the service life and reliability requirements in Verizon applications.

2.0 SCOPE

This VZTPR document specifies the Qualification Requirements for PBAs manufactured with ‘lead-free’ solders to help assure the PBAs will meet the service life and reliability requirements in Verizon applications. These PBAs are for use in either Controlled (Central Office and CEV) or Uncontrolled (OSP and RT) environment applications.

The qualification tests and requirements contained herein shall be used by equipment manufacturers and Verizon certified Independent Test Laboratories as the minimum set of requirements and tests for PBA qualification. Additional manufacturer-specific tests may be added as needed to properly exercise the materials, technology, design and manufacturing processes used by the manufacturer. In all instances of test planning and test execution, the specified version of the referenced GR documents shall be used. Where no version is specified, the most recent and accepted version of the referenced GR document shall be used.

3.0 REFERENCES

GR-63-CORE	NEBS™ Requirements: Physical Protection Issue 3, March 2006
GR-78-CORE	Generic Physical Design Requirements for Telecommunications Products and Equipment Issue 1, September 1997
GR-357-CORE	Generic Requirements for Assuring the Reliability of Components Used in Telecommunications Equipment Issue 1, March 2001
VZ.TPR.9306	NEBS Requirements for the Physical Design and Manufacture of Telecommunication Products and Equipment Issue 1, November 2008
IEC/MIL/etc.	Various reference test methods and procedures



4.0 ACRONYMS

ENIG	Electroless Nickel Immersion Gold
D/EUT	Device/Equipment Under Test
HASL	Hot Air Solder Leveled
ITL	Independent Test Laboratory
CO	Central Office
CEV	Controlled Environmental Vault
OSP	Organic Solder Preservative
OSP	Outside Plant
PB	Printed Board (Bare, unpopulated board)
PBA	Printed Board Assembly (PCB and PWB also used)
RT	Remote Terminal
RoHS	Restriction on Hazardous Substances
SAC	SnAgCu (Tin, Silver and Copper)
SMOBC	Solder Mask Over Bare Copper
WEEE	Waste Electrical and Electronic Equipment

5.0 DEFINITIONS

Lead-Free: Concentration of Lead and its compounds: < 1000 ppm

RoHS: Six substances restricted for use by the European Community Directive of February 13, 2003. These are:

- | | |
|--|---------------------------------------|
| 1. Lead and its Compounds: | Lead (Pb) < 1000 ppm |
| 2. Mercury and its Compounds: | Mercury (Hg) < 1000 ppm |
| 3. Hexavalent Chromium and its Compounds: | Hexavalent Chromium (Cr+6) < 1000 ppm |
| 4. Cadmium and its Compounds: | Cadmium (Cd) < 100 ppm |
| 5. Polybrominated Biphenyls, Esters & Oxides | PBB, PBBE and PBBO < 1000 ppm |
| 6. Polybrominated Diphenyl Esters: | PBDE < 1000 ppm |

Notes:

1. The following are not EU definitions but industry 'slang' definitions
2. RoHS 6 or RoHS 6/6 compliance is complying with the restriction of all 6 RoHS listed substances, without taking any exemptions.
3. RoHS 5 or RoHS 5/6 compliance refers to RoHS compliance with Pb exemptions. In other words, RoHS 5 compliant parts contain Pb > 1000 ppm, but meet the concentration limits for the other five restricted substances (Hg, Cr+6, Cd, PBB and PBDE).



6.0 APPLICABILITY

The qualification tests specified in this document apply to all PBAs that are:

1. Intended for delivery to Verizon
2. Manufactured with lead-free solder
3. Designed and manufactured in conformity to GR-357-CORE, GR-78-CORE and within the Technology and Reliability boundaries specified in Section 7.3 below

7.0 EFFECTIVE DATE

The effective date of this TPR shall be June 1, 2010. As of this date, all equipment supplied to Verizon using lead-free solder shall meet the requirements as defined in this document.

8.0 BACKGROUND

8.1 General

European Union Directives on Waste Electrical and Electronic Equipment (WEEE) and on Restriction of Hazardous Substances (RoHS) prohibit the use of lead in electronic equipment from July 1, 2006. This has resulted in significant efforts over the last few years to find a replacement for the tin-lead alloy solder traditionally used in the manufacture of electronic equipment. Much work has been done and is continuing to be done, to find a replacement for leaded solder. However, no acceptable solution has yet been found.

In the meantime, because of reduced or no availability of components with leaded solder termination finishes, Verizon is receiving more and more requests from suppliers to consider accepting equipment manufactured with lead-free solders. To meet these requests, this document has been prepared. It provides a set of tests for use by all suppliers to Verizon that, in Verizon's view, will help assure equipment delivered to Verizon will meet the service life and reliability requirements in Verizon applications.

8.2 Specifics

Traditional solder is a fusible metal alloy comprising nominally of 60% tin and 40% lead. Solder is used to attach electrical components to a printed board (PB). Solder thus bonds two metal surfaces together - one surface being that of the component termination, the other surface being that of the copper trace on the PB. This bonding occurs at temperatures well below the melting point of either metal. A cross section of the solder joint is thus metal-solder-metal. This results in two metal-solder interfaces. At each interface, the bond is primarily chemical in nature. For good chemical bonding to occur the surfaces to be bonded must be free of contamination and in intimate contact with each other. This is accomplished in the case of soldering because the solder is in the molten state during bond formation. In this molten state, the solder wets the surface of

the metal at the solder-metal interface providing the needed intimate contact. Intimate contact at the interface spontaneously results in chemical bond formation resulting in good electrical continuity between the metal and the solder. In addition, mutual diffusion across the solder-metal interface results in diffusion bond formation. Finally, solder dissolves the metal and board surface finish at the solder-metal interface by solvent action forming new alloys in the vicinity of the solder-metal interface. These alloys have different compositions from that of the original bulk solder – see Figure 1 below.

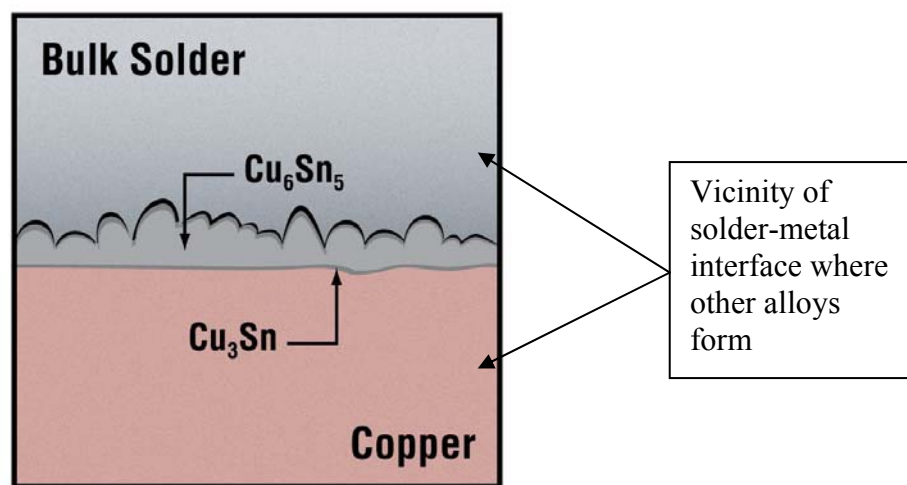


Figure 1 – Cross section of Solder-Metal Interface

Diffusion and solution occurs rapidly when the solder is molten and more slowly when the solder has solidified. Both of these bond types – chemical and diffusion - result in good electrical continuity and strong mechanical attachment at the solder-metal interface.

Solder was initially used only to provide electrical interconnection between the terminations of electrical components and the copper traces on a printed board (PB). However, current printed board assemblies (PBAs) primarily use surface mount technology. This requires that solder provide both the electrical interconnection between the component terminations and the copper traces of the PB as well as the mechanical attachment of the component to the copper traces on the printed board. Leaded solder has a proven track record demonstrating that it meets these requirements. However, it is still to be demonstrated that lead-free solder meets both requirements. This deficiency is further exacerbated because there is no agreed 'standard' lead-free alloy composition. Almost all possible tin and other metals (particularly silver) alloy compositions are available and have been used by industry. This has led to a very confused state within the industry.



To make progress in this confused lead-free situation, an analysis of the available solutions to qualify products manufactured using lead-free solder was conducted. Qualification requires demonstration that lead-free solders meets both of the above requirements, i.e., good electrical interconnection between the component termination and strong mechanical attachment of the component to the copper traces on the PB. The analysis showed lead-free qualification can be accomplished by several methods including the following:

1. Qualifying test vehicles or coupons using tests designed to exercise the design rules and manufacturing processes used by the manufacturer. In this case, if the test vehicles conform to the test requirements, all board designs from the manufacturer, produced on the same manufacturing line as the test vehicles, are deemed to be qualified.
2. Qualifying a test PBA designed to be representative of all board designs from a specific manufacturer. In this case, if the test PBA conforms to the specified test requirements, all board designs from the manufacturer, produced on the same manufacturing line/s as the test PBA, are deemed to be qualified.
3. Qualifying an individual PBA design by subjecting it to the 'catalog of tests' specified in Table 4 below to exercise the lead-free solder system. If the PBA conforms to the specified test requirements, then that specific PBA design is deemed to be qualified. This method is to be supplemented by a physical design and manufacturing analysis at the assembly site to verify conformity to the specified Technology and Reliability boundaries and to the Reliability Monitoring Tests done in manufacturing.

Industry has struggled for many years to develop suitable test vehicles or test PBA designs as required by methods 1 and 2 above. It is not expected that acceptable solutions for these test methods will soon be available. For expediency, method 3 above, using individual PBAs, is the one currently adopted in this document. It avoids the need to develop special test vehicles or test boards. However, with this method, each individual PBA will need to be qualified. This is similar to the qualification process used for electrical, optical or other components attached to the board. It may be possible in the future to treat PBAs on a family basis in a fashion similar to that currently used for components. It is expected that, as the other lead-free qualification methods are developed, they will be added to this document as alternative lead-free qualification options.

The qualification tests specified for qualification method 3 were selected based on their ability to accelerate the underlying failure mechanism. Examples of these tests and the associated failure mechanisms accelerated are given in Table 4.

Use of qualification method 3 assumes the PBA to be qualified is designed and manufactured in conformity to the requirements of GR-357-CORE and GR-78-CORE and within the Technology and Reliability boundaries as defined in Tables 1 through 3 below. Verification of conformance to these latter boundary conditions is to be determined by a physical design and manufacturing facilities analysis at the manufacturing site.



8.3 Technology and Reliability Boundaries

8.3.1. Applicable Printed Board Assembly (PBA) Technologies

Single Sided Surface Mount (SMT) or Through Hole Technology (THT) through to Mixed SMT and THT Double Sided PBA Technologies.

8.3.2. Applicable Material Technologies

Table 1 - Material Types for Backplanes and Daughter Cards

Feature	Press Fit Backplanes	SMT / PTH / Press Fit Daughter Cards
Laminate	Pre-preg (B stage): woven glass, flame retardant epoxy (FR-4), with a minimum $T_g = 130^\circ\text{C}$ CORES (C stage): woven glass, flame retardant epoxy (FR-4), with a minimum $T_g = 130^\circ\text{C}$	Pre-preg (B stage): woven glass, flame retardant epoxy (FR-4), with a minimum $T_g = 130^\circ\text{C}$ CORES (C stage): woven glass, flame retardant epoxy (FR-4), with a minimum $T_g = 130^\circ\text{C}$
Number of Inner Layers	11 maximum	20 maximum
Flux	Hot oil reflow (Shipley Evenflow 1073 or equivalent)	Hot oil reflow (Shipley Evenflow 1073 or equivalent)
Solder Mask	Thermally Cured (PC401, SR1000 or equivalent)	LPI (Taiyo, Enthone, Morton or equivalent)
Legend Ink	Thermally Cured	Thermally Cured



8.3.3. Applicable Component Technologies

Table 2 – Component Criteria for Backplanes and Daughter Cards

Feature	Press Fit Backplanes	SMT / PTH / Press Fit Daughter Cards
Attachment Process	Wave or Re-Flow Solder	Wave or Re-flow Solder
SMT Resistor Size Range	0402, 0603, 1206 & 2512	0402, 0603, 1206 & 2512
THT Resistor Termination	1.0 mm max.	1.0 mm max.
SMT Capacitor Size Range	0402, 0603, 0805 & 1206	0402, 0603, 0805 & 1206
THT Capacitor Termination	1.0 mm max.	1.0 mm max.
P-Dual in-line package	48 Pins Max	48 Pins Max
C-Dual in-line package	48 Pins Max	48 Pins Max
Quad Flat Pack	240 Pins Max	240 Pins Max
C-Leadless Chip Carriers	80 Pins max	80 Pins max
P- Leadless Chip Carriers	80 Pins max	80 Pins max
Small Outline ICs	20 Pins max	20 Pins max
Ball Grid Arrays	1.27 to 0.8 mm	1.27 to 0.8 mm
All Other Components	As per board design	As per board design

SMT = Surface Mount Technology; THT = Through Hole Technology
 C = Ceramic; P = Plastic



8.3.4. Applicable Bare Board Technologies

Table 3 - Physical Criteria for Backplanes and Daughter Cards

Feature	Press Fit Backplanes	SMT / PTH / Press Fit Daughter Cards
Board Thickness	0.240" maximum	0.093" maximum
Panel Size	18" × 24" (or smaller)	18" × 24" (or smaller)
Line Width/Spacing	0.006"/0.006"	0.005"/0.005"
Aspect Ratio	8.47:1	6.9:1
Drilled Hole Size	0.028" minimum	0.0135" minimum via 0.040" minimum through hole
Finished Hole Size	0.024"	0.010" via 0.035" through hole
Finished Hole Size Tolerance	±0.002"	+0.003", -0.010" via ±0.003" through hole
Dielectric Thickness	0.004" minimum	0.004" minimum
Layer Count	16 maximum	20 maximum
Copper Thickness (inner signal layer)	1 oz. maximum	1 oz. maximum
Copper Thickness (inner power and ground layers)	2 oz. maximum	2 oz. maximum
Copper Thickness (outer layers)	1 oz. minimum	0.5 oz. minimum



Feature	Press Fit Backplanes	SMT / PTH / Press Fit Daughter Cards
Board Surface Finish	Solder Mask over bare Copper with Hot air solder level (SMOBC/HASL)	Solder Mask over bare Copper with Hot air solder level with or without gold tips
	Organic Solder Preservative (OSP)	Organic Solder Preservative (OSP)
	Electroless Nickel Immersion Gold (ENIG)	Electroless Nickel Immersion Gold (ENIG)
	Matte Tin (Sn) Electroplate	Matte Tin (Sn) Electroplate
	Immersion Silver	Immersion Silver
Surface Mount Pitch	N/A	25 mils minimum



8.4 Test Effectiveness

Table 4 – Failure Accelerating Tests for Lead-Free Systems

Failure Mode and/or Failure Mechanism	Stabilization Bake	Temp. Cycle/ Thermal Shock	Temperature Cycling/Humidity	Temperature Cycling/Vibration	Power Cycling	Temperature/ Humidity Bias	Mech. Shock/ Acc./Vibration	Salt Fog/Mixed Flowing Gas	Reverse Bias/ Temp.	Dynamic Operation/ Temp.	Board Bend	In-Circuit and Functional	X-Ray/Sectioning Examination	External Visual	SIR/SEC/EMR
TCE Mismatch		•			•										
Tensile Fracture of Solder Joint							•				•	•	•		
Creep Failure of Solder Joint			•	•							•	•	•	•	
Fatigue Failure of Solder Joint		•	•	•	•		•					•			
Component Termination Fracture							•								
Whisker Growth		•	•	•											
SMT Attach Defect		•					•			•			•		
PB Plated Hole Fracture			•	•											
PB Surface Contamination	•								•	•					•
PB Surface Leakage	•								•	•					•
Foreign Materials/Particles							•						•		
Cracked SMT Component		•					•			•					
Cracks in Solder Joint		•							•	•			•	•	
Voids in Solder Joint		•							•	•			•	•	
Solder Mask Defects		•							•						
Open Copper Tracks		•							•	•					
Shorted Copper Tracks		•	•			•		•	•	•					
Lifted Copper Pads		•							•	•				•	
Electromigration										•					•
Intermetallic Formation	•	•								•			•	•	
Solder Joint Embrittlement	•	•					•				•				
Corroded Component Termination		•				•		•	•	•				•	



9.0 QUALIFICATION REQUIREMENTS FOR LEAD-FREE PBAs

9.1 Execution of Tests

Verizon requires that manufacturers submit samples of their PBAs, to a Verizon certified ITL to conduct qualification testing and verification of conformance to the lead-free PBA test requirements specified in this document.

For a list of Verizon certified laboratories and locations, consult the Verizon web page at: <http://www.verizonnebs.com/tcpage.html>.

Qualification Requirements for PBAs manufactured with lead-free solders used in Telecommunications Equipment purchased by Verizon are detailed below in Table 5 - Qualification Requirements for Lead-Free PBAs. Conformance to the tests listed in the Material and Component Levels of Table 5 may be declared by the manufacturer based on manufacturer internal or supplier provided data. However, all tests in Table 5 at the PBA Level shall be executed by the manufacturer selected ITL. Reporting of the test results at all levels shall be done by the ITL in a 'Lead-Free Test Conformance Report'. The equipment manufacturer shall provide this 'Lead-Free Test Conformance Report' to Verizon as part of the NEBS conformance testing and reporting program.

Table 5 is designed to not only provide the required tests and declarations but to also provide the required format for reporting the design/measured values and summarizing their conformance to requirements. The qualification tests specified were selected based on their ability to accelerate the underlying failure mechanism. Examples of these tests and the associated failure mechanisms accelerated are given in Table 4.

Solder joint reliability is a complex function of the solder alloy composition, the solder-metal interface systems, the processing conditions used and the end-use environment. The tests specified in Table 5 below are not exhaustive. They represent a reasonable set of the known state-of-the-art tests that, in Verizon's view, would help assure lead-free PBAs will meet the service life and reliability requirements in Verizon applications. PBA manufacturers shall provide their selected ITL with the tests results of any other manufacturer-specific tests they consider applicable to and necessary for properly exercising the materials, technology, design and manufacturing processes used for their specific PBAs. The ITL shall include these manufacturer-specific tests and test results as supplementary information in the 'Lead-Free Test Conformance Report'.



9.2 Test References

The test references cited in Table 5 are intended to outline the general test methods and procedures to be used to evaluate the applicable requirement. The test conditions specified in Table 5 shall be used and where applicable, shall override those specified in the cited reference. Other test methods (IEC, Joint Electron Device Engineering Council [JEDEC], etc.) may be acceptable alternatives to the cited references. However, use of alternative test methods, procedures sampling plans, etc. will require demonstration that the proposed procedure is equivalent to or is better (from a user's viewpoint) than the specified procedure.

9.3 Sample Size and Accept Criteria

1. At the component, bare board and test coupon level, the sample size and accept criteria used shall be as appropriate for the specified test.
2. At the PBA level, the number of PBA samples used shall be selected to ensure a minimum of 3891 solder joints are used for each test with an accept number of 1 (LTPD of 0.1%). Parallel or sequential testing may be used to maximize test coverage and to optimize use of test samples. Where sequential testing is used, precautions shall be observed to ensure no destructive tests are done within the test sequence.



Table 5 – Qualification Requirements for Lead-Free PBAs

Item Ref. #	Parameter/Test Item	Item Source Ref./Test Procedure	Requirement/ Required Value	Measured/Design Value	Conforms? Y/N
Material Level Criteria/Declarations					
1.	T _G : Glass transition temperature of all polymeric materials	TPR-9306 and GR-1221: R4-24	≥ 95°C		
2.	T _{HDT} : Heat distortion temperature of all polymeric materials	TPR-9306 and This document	≥ 150°C		
3.	OIT: Oxidative Induction Time of all polymeric materials	TPR-9306 ASTM D 3895 and GR-20[138]	20 minutes minimum after aging at 90°C for 14 days		
4.	Melt Flow/Melt Volume Index of all polymeric materials	This document	Verify conformity to specification per ASTM D1238		
5.	Thermal Aging of all polymeric materials	GR-771: 6.4.1 and GR-771: R5-11[85]	90°C for 30 days; 1. No visible deterioration, deformation, melting or cracking. 2. < 20% degradation in mechanical properties.		
6.	Component outer encapsulation material	TPR-9306 GR-78: [695, 696]	Shall withstand 85°C minimum.		
7.	Printed board laminates, solder masks, legend and marking inks, repair polymer and adhesive materials	This document	Shall withstand 85°C minimum.		
8.	Glass Transition temperature of Label Attach Adhesives T _G	1221: R4-24	≥ 95°C		
9.	Glass Transition temperature of printed board laminates	This document	Shall exceed 130°C		



Item Ref. #	Parameter/Test Item	Item Source Ref./Test Procedure	Requirement/Required Value	Measured/Design Value	Conforms? Y/N
Component /Bare Board (PB)/Test Coupon Level Criteria/Declarations					
10.	Component Solderability	MIL-STD-883 G , 2003.8	255°C ± 5°C; 5 secs. max		
11.	Component Resistance to Solder Heat	MIL-STD-202 G, Method 210F	350°C; 30 secs. Min.		
12.	Bare Printed Board Solderability	IPC/EIA J-STD-003A Methods A, D or E as appropriate	255°C ± 5°C; 5 secs. max		
13.	Surface Insulation Resistance	GR-78 Section 13.1.4 78: R14-4	1 × 10 ⁴ megohms		
14.	Solvent Extract Conductivity	78: R6-193	1 mg/cm ²		
15.	Electro Migration Resistance	GR-78 Section 13.1.4 R13-19 R13-20	< 1 decade change No filament growth		
16.	Whisker Growth Evaluation	JEDEC STD # 22A121; IEC-68-2-82 IEC-PAS-62483	Whisker Density = None to Low		
17.	Time to delamination at 260°C after conditioning for 1000 hrs. at 85°C and 85% RH	IPC – 650 – 2.4.24.1 (TMA)	T260 = 1 minute minimum		
18.	Thermal Stress (Solder Float) after 85°C/85% RH for 1000 hrs.	GR-78 14.3.4	Use lead-free solder. 20 seconds at 550°F (287°C). No delamination, wedge void or other damage		
19.	Voltage Breakdown	GR-78 R6-199	No breakdown or flashover		
20.	Shear strength of SMT solder joint after conditioning for 1000 hrs. at 85°C and 85% RH	JIS Z3198-7 or equivalent (specify)	Record initial value and final value after conditioning		



Item Ref. #	Parameter/Test Item	Item Source Ref./Test Procedure	Requirement/ Required Value	Measured/Design Value	Conforms? Y/N
Printed Board Assembly (PBA) Level Criteria/Requirements					
21.	Initial X-Ray Inspection	MIL-STD-883 G , 2012.7	No detectable voids or cracks in solder joint		
22.	Initial External Visual Examination	This document	With back lighting @ 10X; No visible damage, debris, cold joints, contamination or evidence of filament growth		
23.	In Circuit (ICT) and Functional (FCT)	This document	Shall pass ICT and FCT @ 25°C before and after all tests		
24.	Mechanical Shock (Impact) – not operating	MIL-STD-202 G, 213B	5 cycles in each of two directions for three axes; 20g, 11 ms. half sine pulse per impact; Shall pass ICT and FCT before and after conditioning; No physical damage.		
25.	Mechanical Vibration	MIL-STD-883 G , 2007.3	Maximum of 20g or 0.060” DAP; 10 to 2000 Hz in 4 minutes; 12 sweeps per axis; Shall pass ICT and FCT before and after conditioning; No physical damage.		
26.	Thermal Shock	MIL-STD-883 G , 1011.9	$\Delta T = 55^{\circ}C(-5^{\circ}C$ to $+50^{\circ}C)$; two chamber method; Dwell ≥ 5 minutes at temperature extremes or until thermal stability is reached; No. of Cycles = 20; Shall pass ICT and FCT before and after conditioning; No physical damage.		



Item Ref. #	Parameter/Test Item	Item Source Ref./Test Procedure	Requirement/ Required Value	Measured/Design Value	Conforms? Y/N
27.	Temperature Cycling (Dry – not operating)	GR-1209: 5.4.1.5	100 cycles; Shall pass ICT and FCT before and after conditioning; No physical damage.		
28.	Damp Heat Cyclic (not operating)	GR-1209: 5.4.2.1 – C 5.4.2.2 – U	42 cycles; Shall pass ICT and FCT before and after conditioning; No physical damage.		
29.	Damp Heat Steady State - Not Operating (High Temperature/High Humidity: 85°C/85% RH; 1000 hours)	IEC-68-2-67 Test Cy	1000 hours; Shall pass ICT and FCT before and after conditioning; No physical damage.		
30.	Thermal Cycling with Mechanical Vibration and X-Ray	IEC-68-2-53 Test GR-1209: 5.4.1.5	C = -5 °C to +50°C U = -40 °C to +85°C; Dwell times at temp. extremes = 16 minutes minimum; 5-2000 Hz random vibration applied 8 minutes before end of temp extreme periods; Shall pass ICT and FCT before and after conditioning; No physical damage, cracks or void formation in solder joints.		
31.	Power Cycling at Steady Temperature	MIL-STD-202G Method 108A This document	T _{AMB} = + 50°C (C) or +85°C (U); 100 hours; Power on for 10 minutes; Power off for 10 minutes; Shall pass ICT and FCT before and after conditioning; No physical damage		



Item Ref. #	Parameter/Test Item	Item Source Ref./Test Procedure	Requirement/Required Value	Measured/Design Value	Conforms? Y/N
32.	Salt Fog	MIL-STD-202G Method 101E This document	35°C , 10 days, 5% Solution Shall pass ICT and FCT before and after conditioning; No physical damage.		
33.	High Temperature with as many devices Reverse Biased as possible	MIL-STD-883 G , 1015.9	T _{AMB} = + 50°C (C) or +85°C (U); Shall pass ICT and FCT before and after conditioning; No physical damage.		
34.	High Temperature Storage	GR-1221 6.2.4 (EIA/TIA 455-4A)	85°C for 2000 hours; Shall pass ICT and FCT before and after conditioning; No physical damage.		
35.	Low Temperature Storage	GR-1221 6.2.6 (EIA/TIA 455-4A)	-40°C for 2000 hours; Shall pass ICT and FCT before and after conditioning; No physical damage.		
36.	Dynamic Operation at High Temperature - Dry (HTOL)	MIL-STD-202G Method 108A This document	T _{AMB} = + 50°C (C) or +85°C (U); 1000 hours; Shall pass ICT and FCT before and after conditioning; No physical damage.		
37.	Mixed Flowing Gas	GR-63 Sect. 4.5, 5.5.2 and 5.5.3	Shall pass ICT and FCT before and after either Indoor (C) or Outdoor (U) conditioning		
38.	Hydroscopic Dust	GR-63 Sect. 4.5 and 5.5.3	Shall pass ICT and FCT before and after either Indoor (C) or Outdoor (U) conditioning		



Item Ref. #	Parameter/Test Item	Item Source Ref./Test Procedure	Requirement/ Required Value	Measured/Design Value	Conforms? Y/N
39.	Board Bend and X-Ray	IPC 9702 or IPC 9704 – specify which. OR IE384-1: Three point method.	Cylinder Diameter = 2"; Board = lengthwise; bend at CL; Board Edge Deflection = 1:6 Span = 90mm; Board Thickness = 1.6 mm; Displacement = 2.0 mm No. of Cycles = 100; ICT and FCT before and after conditioning; No physical damage.		
40.	Joint Cross Sectional Microstructure and Metallurgical Examination	This document	Assess for intermetallics, cracks and void formation: 1. Five non-Failed control joints before testing 2. All failed joints 3. Five samples of Non-Failed Joints tested 4. Compare both failed and non-failed joints to the control sample and assess for acceptability		
41.	Failure Rate Estimation	This document (As a guide, the failure rate of a SnPb solder joint is estimated at 4×10^{-4} FITS)	Record all solder joint failures from the entire test program. Use this number together with an estimate of all joints tested and an Activation Energy of 0.8 eV to estimate the joint failure rate.		



Item Ref. #	Parameter/Test Item	Item Source Ref./Test Procedure	Requirement/Required Value	Measured/Design Value	Conforms? Y/N
Operating Environment References					
C = Controlled Environments (CO & CEV)					
42.	Ambient Operating Temperature Range	GR-1209: Section 3.7 & Table 3-1	+5°C to +40°C	-	-
43.	Ambient Operating Humidity Range	GR-1209: Section 3.7 & Table 3-1	5% to 85% RH	-	-
44.	Ambient Storage Temperature Range	GR-1209: Section 3.7 & Table 3-1	-40°C to +85°C	-	-
U = Un-Controlled Environments (OSP, RT & Cabinets without Fans)					
45.	Ambient Operating Temperature Range	GR-1209: Section 3.7 & Table 3-1	-40°C to +65°C	-	-
46.	Ambient Operating Humidity Range	GR-1209: Section 3.7 & Table 3-1	5% to 85% RH	-	-
47.	Ambient Storage Temperature Range	GR-1209: Section 3.7 & Table 3-1	-40°C to +85°C	-	-

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