

JEDEC STANDARD

Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes

JESD201

MARCH 2006

JEDEC SOLID STATE TECHNOLOGY ASSOCIATION



NOTICE

JEDEC standards and publications contain material that has been prepared, reviewed, and approved through the JEDEC Board of Directors level and subsequently reviewed and approved by the JEDEC legal counsel.

JEDEC standards and publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for use by those other than JEDEC members, whether the standard is to be used either domestically or internationally.

JEDEC standards and publications are adopted without regard to whether or not their adoption may involve patents or articles, materials, or processes. By such action JEDEC does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the JEDEC standards or publications.

The information included in JEDEC standards and publications represents a sound approach to product specification and application, principally from the solid state device manufacturer viewpoint. Within the JEDEC organization there are procedures whereby a JEDEC standard or publication may be further processed and ultimately become an ANSI standard.

No claims to be in conformance with this standard may be made unless all requirements stated in the standard are met.

Inquiries, comments, and suggestions relative to the content of this JEDEC standard or publication should be addressed to JEDEC at the address below, or call (703) 907-7559 or www.jedec.org

Published by
©JEDEC Solid State Technology Association 2005
2500 Wilson Boulevard
Arlington, VA 22201-3834

This document may be downloaded free of charge; however JEDEC retains the copyright on this material. By downloading this file the individual agrees not to charge for or resell the resulting material.

**PRICE: Please refer to the current
Catalog of JEDEC Engineering Standards and Publications online at
<http://www.jedec.org/Catalog/catalog.cfm>**

Printed in the U.S.A.
All rights reserved

PLEASE!

DON'T VIOLATE
THE
LAW!

This document is copyrighted by JEDEC and may not be reproduced without permission.

Organizations may obtain permission to reproduce a limited number of copies through entering into a license agreement. For information, contact:

JEDEC Solid State Technology Association
2500 Wilson Boulevard
Arlington, Virginia 22201-3834
or call (703) 907-7559

ENVIRONMENTAL ACCEPTANCE REQUIREMENTS FOR TIN WHISKER SUSCEPTIBILITY OF TIN AND TIN ALLOY SURFACE FINISHES

Foreword

This standard was generated under the auspices of the JEDEC JC14.3 Subcommittee on Silicon Device Reliability Qualification and Monitoring and the iNEMI Tin Whisker User Group. It is intended to provide a uniform environmental acceptance testing and reporting methodology for tin whisker susceptibility of tin and tin alloy surface finishes used in the Electronics Industry.

Introduction

Many companies in the electronics industry have adopted tin-based surface finishes as one of the methods to comply with various legislative lead-free (Pb-free) initiatives, e.g., the European Union's RoHS directive. However, tin (Sn) and tin alloy surface finishes may be prone to tin whisker formation with associated possible reliability degradation. Appropriate mitigation practices, as described in JEDEC guidance document JP002, may be incorporated to reduce tin whisker propensity to an acceptable level.

Test conditions per JESD22-A121, Test Method for Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes, and qualification limits presented in this document are based on known Sn-whisker data from around the globe. These test conditions have not been correlated with longer environmental exposures of components in service. Thus, there is at present no way to quantitatively predict whisker lengths over long time periods based on the lengths measured in the short-term tests described in this document. At the time of writing, the fundamental mechanisms of tin whisker growth are not fully understood and acceleration factors have not been established. Therefore, the testing described in this document does not guarantee that whiskers will or will not grow under field life conditions.

ENVIRONMENTAL ACCEPTANCE REQUIREMENTS FOR TIN WHISKER SUSCEPTIBILITY OF TIN AND TIN ALLOY SURFACE FINISHES

(From JEDEC Board Ballot JCB-05-149, formulated under the cognizance of the JC-14.3 Subcommittee on Silicon Devices Reliability Qualification and Monitoring.)

1 Scope

The methodology described in this document is applicable for environmental acceptance testing of tin based surface finishes and mitigation practices for tin whiskers. This methodology may not be sufficient for applications with special requirements, (i.e., military, aerospace, etc.). Additional requirements may be specified in the appropriate requirements (procurement) documentation.

This specification is intended for use in conjunction with JESD22A121, This specification does not apply to components with bottom-only terminations where the full plated surface is wetted during assembly (for example: QFN and BGA components, Flip Chip bump terminations).

2 Normative reference

JESD22A121, *Test Method for Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes*

JESD22-A104, *Temperature Cycling*

JP002, *Current Tin Whisker Theory and Mitigation Practices Guideline*

3 Terms and definitions

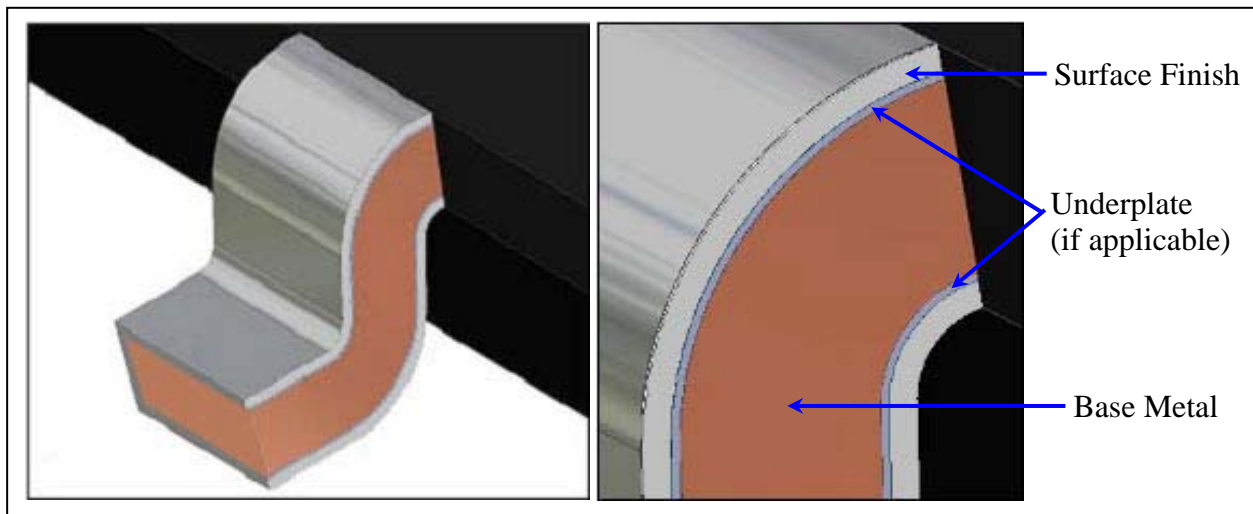


Figure 1 — Cross-sectional view of component surface finishes

base metal: Metal alloy residing beneath all surface finish(es) and/or underplate.

3 Terms and definitions (cont'd)

tin and tin alloy surface finish: Tin-based outer surface finish for external component terminations and other exposed metal.

tin whisker mitigation practice: Process(es) performed during the manufacture of a component to reduce the propensity for tin whisker growth by minimizing the surface finish internal compressive stress.

manufacturing process change acceptance, surface finish: Acceptance testing of a change to a surface finish manufacturing process already accepted by a Technology Acceptance.

similarity acceptance, surface finish: Acceptance of a change to a surface finish manufacturing process based upon similarity and data available from previous tin whisker Technology and Manufacturing Process Change Acceptance tests.

surface corrosion: A localized change to a silver-colored tin surface finish appearing in an optical microscope as non-reflective dark spots ranging in size from about 25 micrometers on the longest dimension to the entire termination.

NOTE While tin oxide is ubiquitous on tin surface finishes, surface corrosion creates a locally thick layer of tin oxide that may span from the substrate to the surface of the deposit at the black spot. Typical photos of termination corrosion are shown in Annex A.

technology acceptance, surface finish: Acceptance testing of surface finish material set and manufacturing processes that includes a defined set of base metals, underplating metals, surface finish alloy, surface finish bath chemistry and process flow steps.

whisker length: The straight line distance from the point of emergence of the whisker to the most distant point on the whisker (i.e., the radius of a sphere containing the whisker with its center located at the point of emergence.).

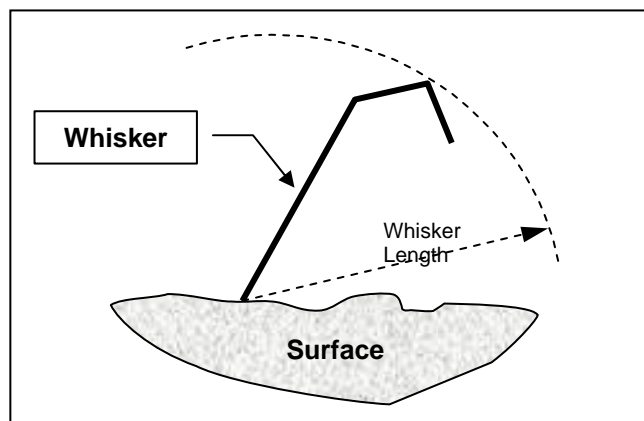


Figure 2 — Whisker length measurement

underplate: Plated layers between the base metal and the outer surface finish.

whisker: A spontaneous columnar or cylindrical filament, usually of monocrystalline metal, emanating from the surface of a finish. (See JESD22A121)

3 Terms and definitions (cont'd)

minimum lead-to-lead gap: The minimum gap between leads (terminations) as shown in Figure 3.

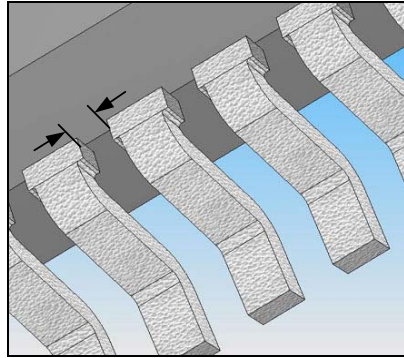


Figure 3 — minimum lead-to-lead gap

4 Test method for measuring tin whisker growth

Except as specifically noted in this document, the procedures for conducting stress testing and inspections for tin whisker growth in JESD22A121, shall be used as applicable to satisfy this acceptance specification. Where differences with JESD22A121 exist this acceptance document takes precedence.

4.1 Test samples

In most cases, individual production components shall be used for the acceptance test. However, for some assembled components with internal tin plated surfaces that cannot be inspected optically, e.g., internal surfaces of cans and hybrid component lids, testing and inspection of piece parts may be necessary. In addition, components with tin or tin alloy surface finishes used in press-fit, socketed applications, or with other compressive mechanical connections, should be qualified in their end use configuration. Additional testing and/or specifications may be needed for testing mechanically loaded components.

4.2 Handling precaution

Careful test sample handling is important in order to avoid possible damage or detachment of whiskers from the test samples. Excessive vibration, impact, or physical contact with the termination finish should be avoided because whiskers may be dislodged. Test sample contamination as a result of improper handling or as a result of the application of a conductive material for SEM inspection should be avoided if the samples are to be returned to the test condition for further exposure, because such material may impact whisker growth behavior. The procedures outlined in JESD22A121 to limit condensation on the samples should also be followed during elevated temperature-humidity testing since condensation increases the likelihood of surface corrosion.

5 Acceptance procedure for tin and tin alloy surface finishes

5.1 Determination of whether a Technology, Manufacturing Process, or Similarity Acceptance test is required

The acceptance requirements for tin and tin alloy finishes depend on the acceptance testing history of the surface finish. For a surface finish without any acceptance testing history, a rigorous technology acceptance test shall be completed as described in section 5.3. If the tin or tin alloy finish has already passed a technology acceptance test, then any change to the manufacturing process or the metallurgy shall be categorized as either a technology change, a manufacturing process change, or a negligible change based on similarity. Table 1 may be used as guidance to differentiate between a technology and a manufacturing process acceptance change. Table 2 shall be used to categorize a change as either a technology change, a manufacturing process change, or a negligible change based on similarity. In addition, Table 2 indicates required testing that is described in detail in Tables 3 and 4 in Section 5.

The acceptance procedure for tin and tin alloy surface finishes shall follow the procedural flow outlined in Figure 4. A specific Surface Finish / Mitigation process or change will necessitate a Technology or Manufacturing Process Change Acceptance unless the change is covered by Similarity. Annex B shows the typical Technology Acceptance test flow, using minimum sample size, for multi-leaded components.

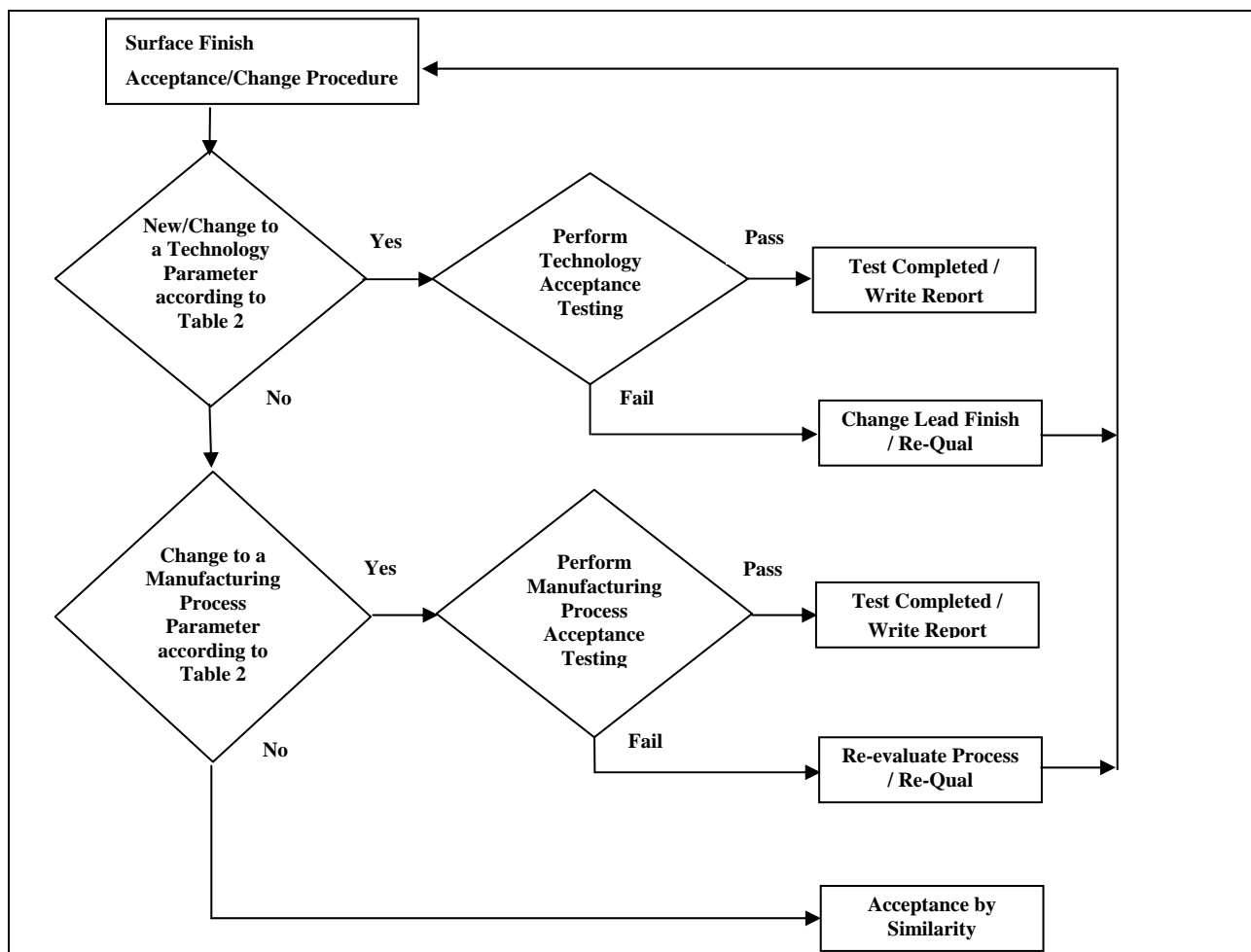


Figure 4 — Flowchart to determine whether a Technology Acceptance Test, a Manufacturing Process Acceptance Test, or no testing is required on the basis of Similarity

5 Acceptance procedure for tin and tin alloy surface finishes (cont'd)

5.1 Determination of whether a Technology, Manufacturing Process, or Similarity Acceptance test is required (cont'd)

The acceptance requirements described in this document apply to a specific tin or tin alloy surface finish. The same surface finish may originate from multiple plating lines and be used on multiple component types, as long as the parameters described in Table 1 are the same. For the purposes of this document, a surface finish is defined by the base metal, surface finish composition, surface finish chemistry and manufacturing process, assembly process and component type, and factory or plating process. These categories are listed in the left column of Table 1. Within these categories, there are major parameters called Technology Parameters and minor parameters called Manufacturing Process Parameters that define the tin or tin alloy surface finish. Any new surface finish must be submitted for a Technology Acceptance Test. In addition, changes to Technology Parameters require a new Technology Acceptance test, and changes to a Manufacturing Process Parameter require a new Manufacturing Process Acceptance test, according to the flowchart in Figure 4.

Table 1 — Surface finish technology and manufacturing process change acceptance parameters

Parameter	Technology parameters	Manufacturing process parameters
Base Metal	<ul style="list-style-type: none"> • Base Metal Composition 	<ul style="list-style-type: none"> • Type, e.g., Etched or Stamped
Surface Finish Composition	<ul style="list-style-type: none"> • Surface Finish Alloy Composition • Surface Finish Thickness • Underplate Composition • Underplate Thickness 	
Surface Finish Chemistry or Manufacturing Process	<ul style="list-style-type: none"> • Surface Finish Plating Process • Process Chemistry • Underplate Process • Underplate Process Chemistry • Dip Process • Dip Process Chemistry • Post Bake Process Parameters • Plating Bath Vendor • Major Plating Process Control Parameters 	<ul style="list-style-type: none"> • Minor Plating Process Control Parameters • Dip Process Control Parameters
Assembly Process and Component Type		<ul style="list-style-type: none"> • Lead Forming Process
Factory or Plating Process	<ul style="list-style-type: none"> • Startup New Factory 	<ul style="list-style-type: none"> • New Plating Equipment

Table 2 lists the Technology and Manufacturing Process Change Acceptance tests required for parameter changes. The details of the tests are described in Table 3 and Tables 4 a-c. Table 2 also defines those changes that are considered negligible and do not require additional testing, according to the flowchart in Figure 4.

5.1 Determination of whether a Technology, Manufacturing Process, or Similarity Acceptance test is required (cont'd)

Table 2 — Tin and tin alloy surface finish acceptance test matrix

Technology or Manufacturing Process Parameter	Examples	Qual Type ¹	Acceptance Tests Req'd		
			TC ²	T & H	High/T & H
Base Metal					
Base Metal Alloy ³	Base metal, e.g., Cu alloy, FeNi42	T	x	x	x
Base Metal Vendor ⁴	Supplier A vs. B, same metal	S	-	-	-
Leadframe type	Etch vs Stamped	P	x	x	x
Surface Finish Composition					
Surface Finish Alloy	Sn, SnAg3.5, SnBi2-4, SnBi5-7, SnCu1, SnCu3	T	x	x	x
Surface Finish Thickness	Change in thickness limits	T	x	x	x
Underplate Composition	Change in underplate composition	T	x	x	x
Underplate Thickness	Change in thickness limits	T	x	x	x
Surface Finish Chemistry or Process					
Surface Finish Plating Process	In-line vs. Rack vs Barrel, Bright vs. Matte tin ⁷	T	x	x	x
Underplate Process	Change in underplate process	T	x	x	x
Process Chemistry	MSA, Mixed acid, etc.	T	x	x	x
Plating Bath Vendor	Supplier A vs. B	T	x	x	x
Major Plating Process Window Limits	Change beyond process window limits for additive levels, metal content, acid content, current density, temperature, impurity levels	T	x	x	x
Minor Plating Process Window Limits	Change within process window limits for additive levels, metal content, acid content, current density, temperature, impurity levels	S	-	-	-
Dip Process	Change of flux, impurity levels, immersion rate, cooling rate, etc.	T	x	x	x
Post Bake Process	Change in bake process parameters	T	x	x	x
Assembly Process and Component Style					
Lead Form	J-lead vs. gull wing	S	-	-	-
Lead Count	Different lead count	S	-	-	-
Lead Dimension	e.g., 0.25 mm wide, 0.18 mm wide	S	-	-	-
Factory or Plating Process⁵					
Startup New Factory	New Factory	P ⁶	x	x	x
		T	x	x	x
New Plating Line (Duplicate)	Accepted Technology/Factory/Vendor	S	-	-	-
New Plating Equipment	New plating line, vendor, or relocation of a line	P	x	x	x

5 Acceptance procedure for tin and tin alloy surface finishes (cont'd)

5.1 Determination of whether a Technology, Manufacturing Process, or Similarity Acceptance test is required (cont'd)

Table 2 — Tin and tin alloy surface finish acceptance test matrix (cont'd)

NOTE 1	T = Technology Acceptance; P = Manufacturing Process Change Acceptance; S = Similarity Acceptance
NOTE 2	For Manufacturing Process Change Acceptance, TC test may be omitted if the CTE (coefficient of thermal expansion) of the base metal is >15 ppm/K. If an underplate is used, TC may be omitted only if the CTE of both the underplate and base metal is >15 ppm/K.
NOTE 3	Technology Acceptance testing is not required for changes to copper alloys if an underplate sufficient to limit copper diffusion into the tin surface finish is used.
NOTE 4	Same base metallurgy/chemistry including any flash metal surface plating.
NOTE 5	Precautions should be taken in regards to maintenance practices, which can result in a change in manufacturing process parameters, which may result in more susceptibility to whisker growth.
NOTE 6	New Factory interim release may be granted based on Manufacturing Process Change Acceptance completion upon agreement between supplier and user. Full factory release will be after successful completion of the technology acceptance testing.
NOTE 7	Definitions of Matt vs. Bright Tin are found in JP002 with regard to grain size and carbon content.

5.2 Samples

5.2.1 Sample requirements

Production samples and surface finishes shall be used for Technology and Manufacturing Process Acceptance testing. The set of production samples used for a single Technology or Process Acceptance test shall be composed of three lots of the same surface finish, according to Table 3. The set of production samples used for a single Technology or Manufacturing Process Acceptance test shall be taken from three lots of the same surface finish, according to Table 3. The required three lots of surface finish may be plated at one-week intervals on the same plating line or may be plated simultaneously on different plating lines within the same factory using the same surface finish, defined by the same Technology and Process parameters that are listed in Table 1. The same samples shall be used at each inspection or readpoint, as described in Section 5.3. Component samples for applications with mechanical connections, i.e. press-fit or socketed, etc. should be qualified in the end use configuration.

5.2.1.1 Lead forms

The samples chosen for the test shall be selected with consideration of the lead form. It is not necessary to test every lead form. For IC and lead type components, the gull wing configuration (if applicable) shall be tested. If not applicable, select the lead form that has the most extreme case of tin deformation due to trim and form operations that occur after plating. For other component types, select the product for testing that has the most extreme case of tin deformation due to trim and form operations (if applicable).

5.2 Samples (cont'd)

5.2.2 Sample size for multi-leaded components

Table 3a specifies the minimum quantity of 3 plating lots, 2 samples from each lot per each of the 3 precondition treatments, making a total minimum of 18 samples per stress test. When the number of terminations per sample part is less than 16, the number of components must be increased to meet the minimum required number of termination inspections, per Table 3a.

5.2.3 Sample size for passive and discrete components with 4 leads or fewer

Table 3b specifies the minimum quantity of 3 plating lots, 3 samples from each lot per each of the 3 precondition treatments, making a total minimum of 27 samples per stress test.

5.2.4 Additional samples

It is recommended that some samples in addition to the minimum shown in Tables 3a and 3b be included for the High Temperature/Humidity Storage test because of the possibility of surface corrosion, which could result in terminations or components being removed from the whisker inspection. As defined in Section 3 and discussed in Section 5.3, terminations or components may be removed from inspection due to surface corrosion. Since terminations or components that are removed due to corrosion must be replaced in order for the test to be valid, it is beneficial to begin testing with extra samples.

Table 3a — Tin and Tin Alloy Surface Finish Acceptance Test Sample Size Requirements per Precondition Treatment for Multi-Leaded Component

Stress Type	Minimum Sampling and Inspection Requirements per Precondition Treatment				
	Lots Per Stress	Samples Per Lot	Components Inspected per Readpoint ¹	Screening Inspection Terminations per Readpoint ²	Detailed Inspection Terminations per Readpoint ³
Temperature Cycling	3	2	6	96	18
Temperature / Humidity Storage	3	2	6	96	18
High Temperature / Humidity Storage	3	2	6	96	18

NOTE 1 Components should be drawn equally from the Manufacturing lots, as much as is practicable.

NOTE 2 Minimum number of terminations inspected during Screening Inspection per readpoint (See JESD22A121).

NOTE 3 If whiskers are detected in the Screening Inspection, then the terminations with the longest whiskers shall be measured in the Detailed Inspection. The longest whisker is measured and recorded for each termination. If no whiskers are detected in the Screening Inspection, then no Detailed Inspection is required, according to JESD22A121.

5.2 Samples (cont'd)

5.2.4 Additional samples (cont'd)

Table 3b — Tin and Tin Alloy Surface Finish Acceptance Test Sample Size Requirements per Precondition Treatment for Passive and Discrete Components with 4 leads or fewer

Stress Type	Minimum Sampling and Inspection Requirements per Precondition Treatment				
	Lots Per Stress	Samples Per Lot	Components Inspected per Readpoint ¹	Screening Inspection Terminations per Readpoint	Detailed Inspection Terminations per Readpoint ²
Temperature Cycling	3	3	9	18	18
Temperature / Humidity Storage	3	3	9	18	18
High Temperature / Humidity Storage	3	3	9	18	18

NOTE 1 Components should be drawn equally from the Manufacturing lots, as much as is practicable.

NOTE 2 The longest whisker is measured and recorded for each termination. If no whiskers are detected in the Screening Inspection, then no Detailed Inspection is required, according to JESD22A121.

5.3 Test procedures and durations

5.3.1 Preconditioning

The Technology Acceptance and Manufacturing Process Acceptance Testing requires that the samples described in Section 5.2 shall be preconditioned prior to test condition exposure, according to Table 4c and JESD22A121.

Depending on the base metal of the surface finish and the mitigation method used, different preconditioning is required prior to performing the Technology or Manufacturing Process Acceptance test, as described in Table 4c. All preconditions for a particular base metal are required for an Acceptance test. Refer to Annex B for a typical schematic of the division of multi-leaded components from 3 lots into 3 preconditions and then into 3 stress types or test conditions.

5.3.2 Test conditions

Tables 4a (Technology Acceptance) and 4b (Manufacturing Process Acceptance) list the stress tests, test conditions, inspection intervals and total durations required for tin whisker acceptance testing of tin-based surface finishes. The User should refer to JESD22A121, for procedures for conducting these tests.

5.3 Test procedures and durations (cont'd)

5.3.3 Test durations

Specific inspection intervals and total test durations shall be used as defined in Tables 4a and 4b. These inspection intervals and total durations depend on the Class level of the product, as per section 5.4, in which the component will be used. A particular surface finish may be tested for acceptability in multiple product Class levels. The product Class affects the inspection intervals and test durations listed in Tables 4a and 4b, as well as the failure criteria given in Tables 5a and 5b.

5.3.4 Whisker inspection

At each inspection interval listed in Tables 4a and 4b, the test samples shall be removed from the stress chamber(s) and inspected by optical microscope and/or SEM according to the procedures specified in JESD22A121. If optical microscopy is used for screening and measurement of whisker length, then validation of the optical equipment must be performed per JESD22A121 prior to inspection of whisker samples.

The same samples shall be used at each inspection readpoint. For example, a high temperature/humidity storage test on multi-leaded components would begin with a minimum of 18 samples (2 samples from each of 3 lots for each of the 3 precondition treatments). Consider one particular precondition treatment with 6 corresponding sample parts. At the 1000-hour readpoint, these 6 samples would be removed from the chamber, 96 terminations would be inspected, and the 18 terminations with the longest whiskers shall have the longest whisker on each termination measured. These 6 samples then would be returned to the thermal chamber and exposed for another 1000 hours. Then, these same 6 samples would be removed at the 2000-hour readpoint, the same 96 terminations would be inspected, and the 18 longest whiskers (not necessarily the same as at the previous readpoint) would be measured. This process would repeat until the test is complete.

The time that samples are out of the chamber for inspection and whisker measurement should be kept to a minimum in order to minimize the overall test time and to avoid inducing artifacts into the whisker measurements. Refer to JESD22A121 for maximum time allowed.

5.3.5 Surface corrosion observed during High Temperature/Humidity Testing

- If surface corrosion is observed, the termination showing corrosion may be removed from the whisker inspection; any termination removed must be replaced with another termination to maintain the total required sample size.
- If one sample part shows evidence of massive corrosion, that sample may be removed as invalid for the test and replaced with another sample. Therefore, additional samples beyond the minimum required in Table 3 may need to be included from the beginning to account for the possibility of removing a corroded sample part from test.
- Any elimination or substitution of sample parts or individual terminations due to corrosion must be documented with appropriate technical justification.

5.3 Test procedures and durations (cont'd)

5.3.5 Surface Corrosion Observed during High Temperature / Humidity Testing (cont'd)

Table 4a — Technology Acceptance Tests and Durations

Stress Type	Test Conditions	Pre-conditioning	Inspection Intervals	Total Duration	
				Class 1 and 2 Products	Class 1A Products ⁵
Temperature Cycling¹	-55 +0/-10 °C to 85 +10/-0 °C, air to air; 10 minute soak; ~3 cycles/h (typ.)	Per Table 4c	500 cycles	1500 cycles	1000 cycles
	-40 +0/-10 °C to 85 +10/-0 °C, air to air; 10 minute soak; ~3 cycles/h (typ.)				
Temperature / Humidity Storage	30 ±2 °C and 60 ±3% RH ²	Per Table 4c	1000 hours	4000 hours ⁴	1000 hours
High Temperature / Humidity Storage	55 ±3 °C and 85 ±3% RH ³	Per Table 4c	1000 hours	4000 hours ⁴	1000 hours

NOTE 1 Either Temperature Cycling Test Condition may be used.

NOTE 2 Previous data generated under uncontrolled ambient conditions may be substituted for this condition.

NOTE 3 Previous data generated under higher humidity conditions, e.g., 60 °C and 90-95% relative humidity (RH), are substitutable for this condition.

NOTE 4 Whisker length data for all inspection intervals shall be recorded and be available, upon request, for all Technology Acceptance tests. The length of the longest whiskers at each inspection interval, from the 18 termination detailed inspection, shall be plotted against the inspection time interval.

NOTE 5 See section 5.4 for definitions of Class levels.

NOTE 6 For Class 1A products, using low CTE (<15 ppm/K , e.g., Alloy 42) leadframe, only the Temperature Cycling test will be performed for Technology Acceptance.

5.3 Test procedures and durations (cont'd)

5.3.5 Surface Corrosion Observed during High Temperature / Humidity Testing (cont'd)

Table 4b — Manufacturing process change acceptance tests and durations

Stress type	Test conditions	Preconditioning	Total duration	
			Class 1 and 2 Products	Class 1A Products ⁴
Temperature Cycling ¹	-55 +0/-10 °C to 85 +10/-0 °C, air to air; 10 minute soak; ~3 cycles/hour (typ.)	Per Table 4c	500 cycles	500 cycles
	-40 +0/-10 °C to 85 +10/-0 °C, air to air; 10 minute soak; ~3 cycles/hour (typ.)		500 cycles	500 cycles
Temperature / Humidity Storage	30 ±2 °C and 60 ±3% RH ²	Per Table 4c	1500 hours	1000 hours
High Temperature / Humidity Storage	55 ±3 °C and 85 ±3 RH ³	Per Table 4c	1500 hours	1000 hours

NOTE 1 Either Temperature Cycling Test Condition may be used.
 NOTE 2 Previous data generated under uncontrolled ambient conditions may be substituted for this condition.
 NOTE 3 Previous data generated under higher humidity conditions, e.g., 60 °C and 90-95% RH, are substitutable for this condition.
 NOTE 4 For Class 1A products, using low CTE (<15 ppm/K, e.g., Alloy 42) leadframe, only the Temperature Cycling test will be performed for Manufacturing Process Change Acceptance.

Table 4c — Preconditioning for Technology/ Manufacturing Process Change Acceptance Testing

Base Metal Alloy	Mitigation Technology	Precondition Treatment ^{1, 2, 3}
Copper Alloys	None	A (no precondition)
		B+C (storage + SnPb reflow)
		B+D (storage + Pb-free reflow)
	Underplate Process or Post Bake Process	A (no precondition)
		C (SnPb reflow) ⁴
FeNi42 (e.g., Alloy 42)	None	D (Pb-free reflow) ⁴
		A (no precondition)
		C (SnPb reflow)
		D (Pb-free reflow)

NOTE 1 Preconditioning treatments per JESD22A121 prior to indicated stresses in Tables 4a and 4b.
 NOTE 2 Reflow assembly is optionally allowed for conditions C and D using the optional preconditioning reflow temperatures from JESD22A121 Table 3. If reflow assembly is used, the number of sample terminations inspected may need to be increased due to the reduction of termination area wetted by the board solder. The inspection increase should be based on achieving approximately the same area as an unwetted termination. Annex C describes the details for the reflow assembly process.
 NOTE 3 The + symbol indicates sequential preconditioning in the order listed.
 NOTE 4 If underplate/post bake process does not conform to JP002 sections 5.3 or 5.4.3 then condition B (4 weeks room ambient storage) must be used before conditions C and D.

5.4 Determination of the Class level for testing

The Class level indicates the test program (test duration and whisker length criteria) used for the surface finish technology acceptance testing. Product Classes shall be agreed to between supplier and user.

General guidelines for product Classes follow but may not apply in all cases:

- Class 3:** Mission/Life critical applications such as military, aerospace and medical applications
 - Pure tin and high tin content alloys are not typically acceptable
- Class 2:** Business critical applications such as Telecom Infrastructure equipment, High-end Servers, Automotive, etc.
 - A whisker mitigation practice is expected, see section 5 of JP002 for examples, unless otherwise agreed between supplier and user.
 - Long product lifetimes and minimal downtime
 - Products such as disc drives typically fall into this category
 - Breaking off of a tin whisker is a concern
- Class 1:** Industrial / consumer products
 - Medium product lifetimes
 - No major concern with tin whiskers breaking off
- Class 1A:** Consumer products
 - Short product lifetimes
 - Minimal concern with tin whiskers

6 Acceptance criteria

Whisker length measurements shall be made at each inspection interval and at the total test duration listed in Tables 4a and 4b, according to procedures in JESD22A121. Each of these measurements shall be compared to the maximum allowable tin whisker length in Table 5a for Technology Acceptance testing and Table 5b for Manufacturing Process Acceptance testing. Any measurement of whisker length that exceeds the appropriate maximum allowable whisker length in Table 5a for Technology Acceptance testing or Table 5b for Manufacturing Process Acceptance testing results in a failure of the surface finish that is being tested. Specifically, a single tin whisker on a single termination that exceeds the appropriate failure criterion in Table 5a or 5b constitutes a failure of the surface finish Technology or Manufacturing Process under test. The appropriate failure criterion or maximum allowable whisker length depends on the product Class determined with guidance from Section 5.4. It is possible for a surface finish to pass 1 or 2 Classes while failing others. For instance, a surface finish could pass the Class 1A Technology Acceptance test, but fail the Class 1 and Class 2 tests.

Generic data on long established tin surface finish manufacturing processes with reliable field histories can be substituted with agreement between supplier and user.

6 Acceptance criteria (cont'd)

Table 5a — Technology Acceptance Criteria for Maximum Allowable Tin Whisker Length

Considerations (Component Type, Lead Pitch or Operating Frequency)	Maximum Allowable Whisker Length			
	Class 3	Class 2	Class 1	Class 1A
2 Lead SMD Components	Pure tin and high tin content alloys are not typically allowed	40 μm for Temperature/Humidity Storage and High Temperature/Humidity Storage 45 μm for Temperature Cycling	67 μm^1	50 μm for Temperature Cycling and High Temperature/Humidity Storage
Multi-Leaded Components			67 μm^1	
High Frequency Components²			50 μm	20 μm for Temperature/Humidity Storage
Components with a minimum lead-to-lead gap >320 μm			100 μm	75 μm

NOTE 1 This spacing accounts for up to 0.05 mm bent leads. The maximum of the 67 μm accounts for adjacent discrete components.

NOTE 2 It is reported that the susceptibility to electrical performance degradation associated with tin whiskers increases with frequency. (RF Components >6 GHz, or Digital Components $T_{\text{rise}} < 59$ ps).

Table 5b — Manufacturing Process Change Acceptance Criteria for Maximum Allowable Tin Whisker Length

Considerations	Stress Type	Maximum Allowable Whisker Length		
		Class 2	Class 1	Class 1A
Components with a lead-to-lead gap ≤ 320 μm	Temperature Cycling	45 μm	50 μm	50 μm
	Temperature / Humidity Storage	20 μm	20 μm	20 μm
	High Temperature / Humidity Storage	20 μm	20 μm	50 μm
Components with a minimum lead-to-lead gap >320 μm	Temperature Cycling	45 μm	50 μm	50 μm
	Temperature / Humidity Storage	20 μm	40 μm	75 μm
	High Temperature / Humidity Storage	20 μm	40 μm	75 μm

7 Reporting of results

At the conclusion of Acceptance testing, a report of background information and findings shall be published including, but not limited to, the following:

Description of the surface finish, defined by Technology and Process parameters in Table 1

- Details of the Mitigation process used on the test samples (per JESD22A121, Annex E).
- Component type, base metal, under layer plating (if any), and surface finish material(s).
- Plating and under layer plating (if any) thickness.

Samples and preconditioning

- Date of plating of each lot and lot identification.
- Precondition treatment and preconditioning temperature profile details.
- Date of preconditioning.

Acceptance testing

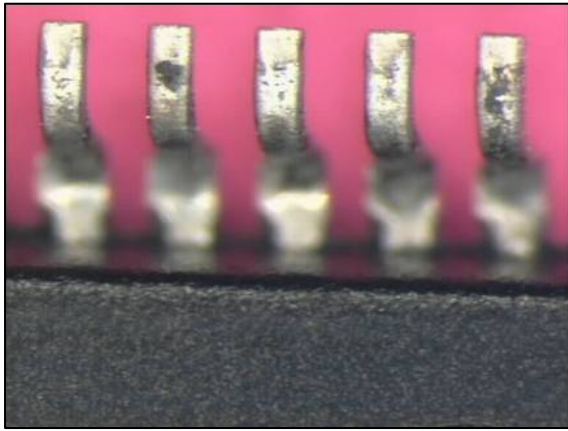
- Type of qualification being performed (technology vs. manufacturing process).
- For a Manufacturing Process Acceptance test, provide a reference to the related Technology Acceptance test.
- Stress conditions (including inspection intervals and duration) and sample sizes utilized in acceptance testing.
- Acceptance criteria utilized and product Class.
- Inspection equipment details including magnifications used (if applicable, the optical inspection qualification data per JESD22A121, Annex B).
- Inspection results for optical and/or SEM inspections per stress condition and interval, including maximum whisker length results for each test at the specified intervals (per JESD22A121, Annex E).
- Identification of any sample parts and/or terminations discounted due to corrosion.
- Conclusion of whether the surface finish has passed or failed the test

8 Ongoing Tin Whisker evaluation

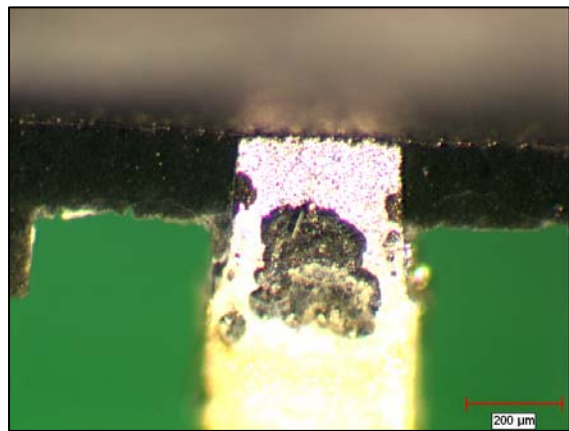
Supplier will establish a system to periodically evaluate the performance of the surface finish manufacturing processes for whisker generation. The specifics of this system are left to the supplier, however, the following minimum guidelines are suggested:

- A representative sample of components taken periodically, as determined by the supplier, should be evaluated for each surface finish technology.
- The storage conditions for these components should include a relative humidity of 60% or greater. Using the temperature/humidity storage test conditions of Table 4 is preferred.
- The samples should be inspected for whiskers 6 months from the date of plating.
- Results should be compared to baseline measurements. If these are exceeded, supplier should take appropriate corrective actions.

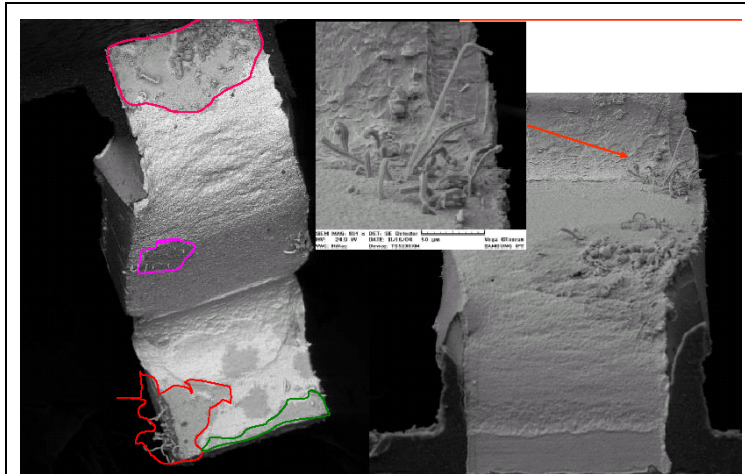
Annex A Typical Photos of Termination Corrosion



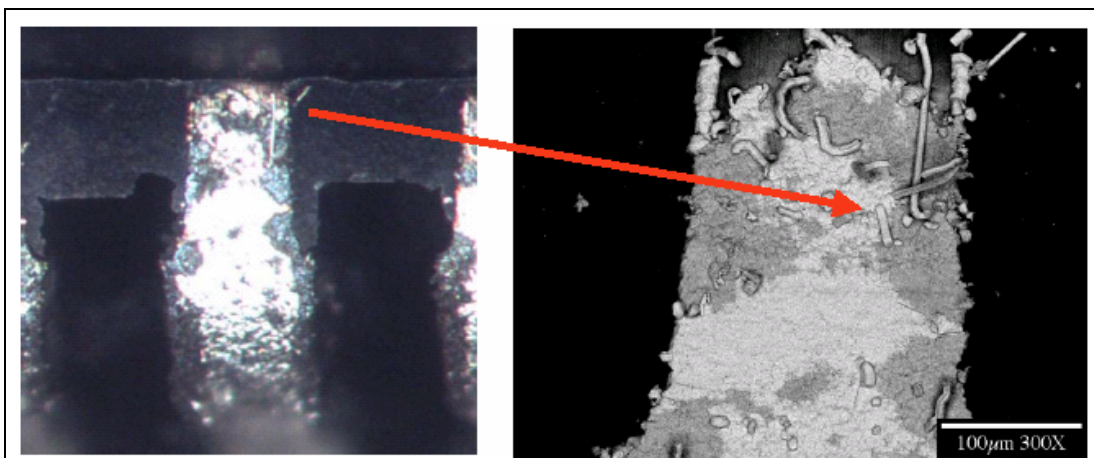
Matte Sn on Cu with Ni plate (Optical)



Matte Sn on Cu (Optical)

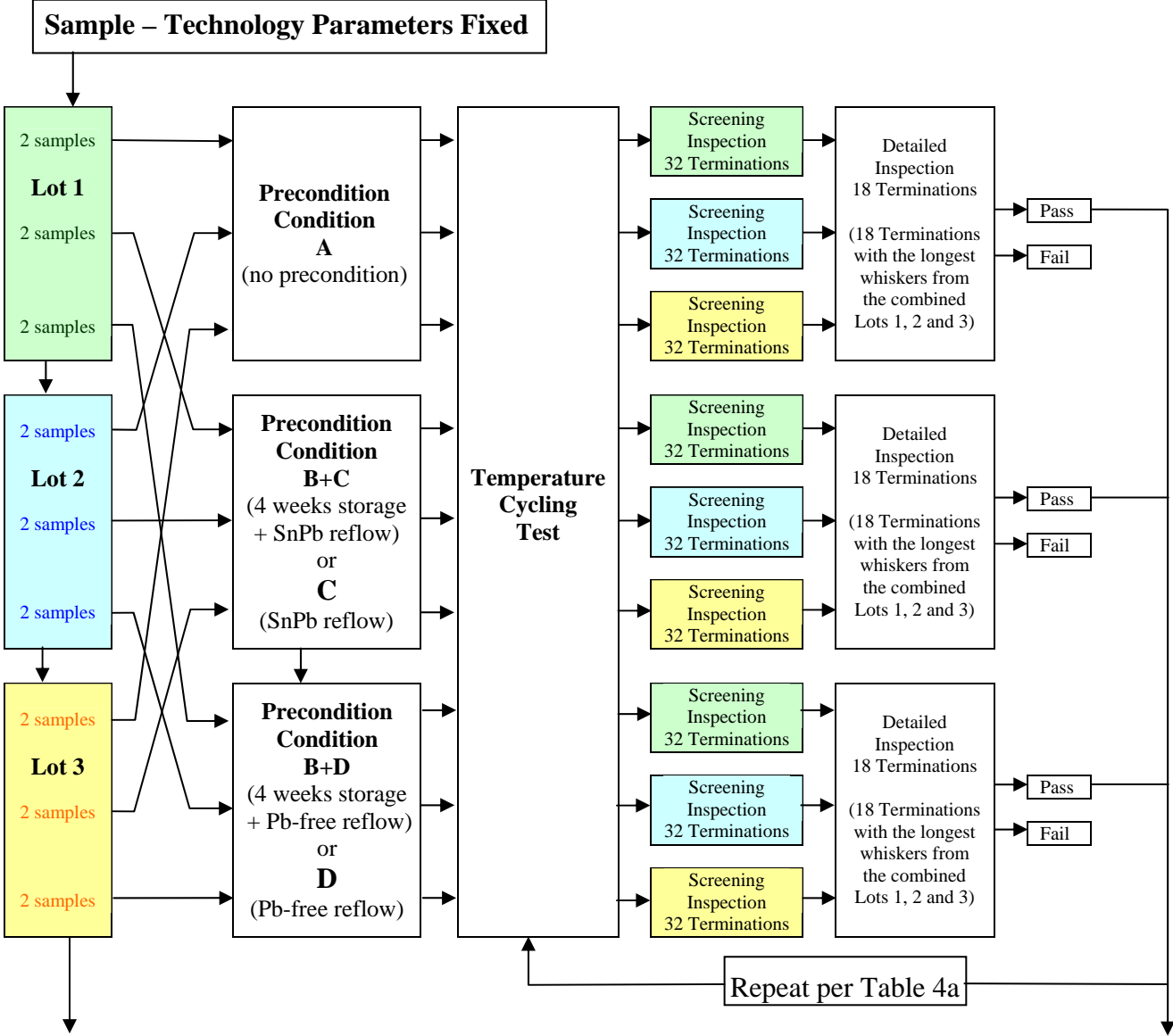


Matte Sn on Cu (SEM)

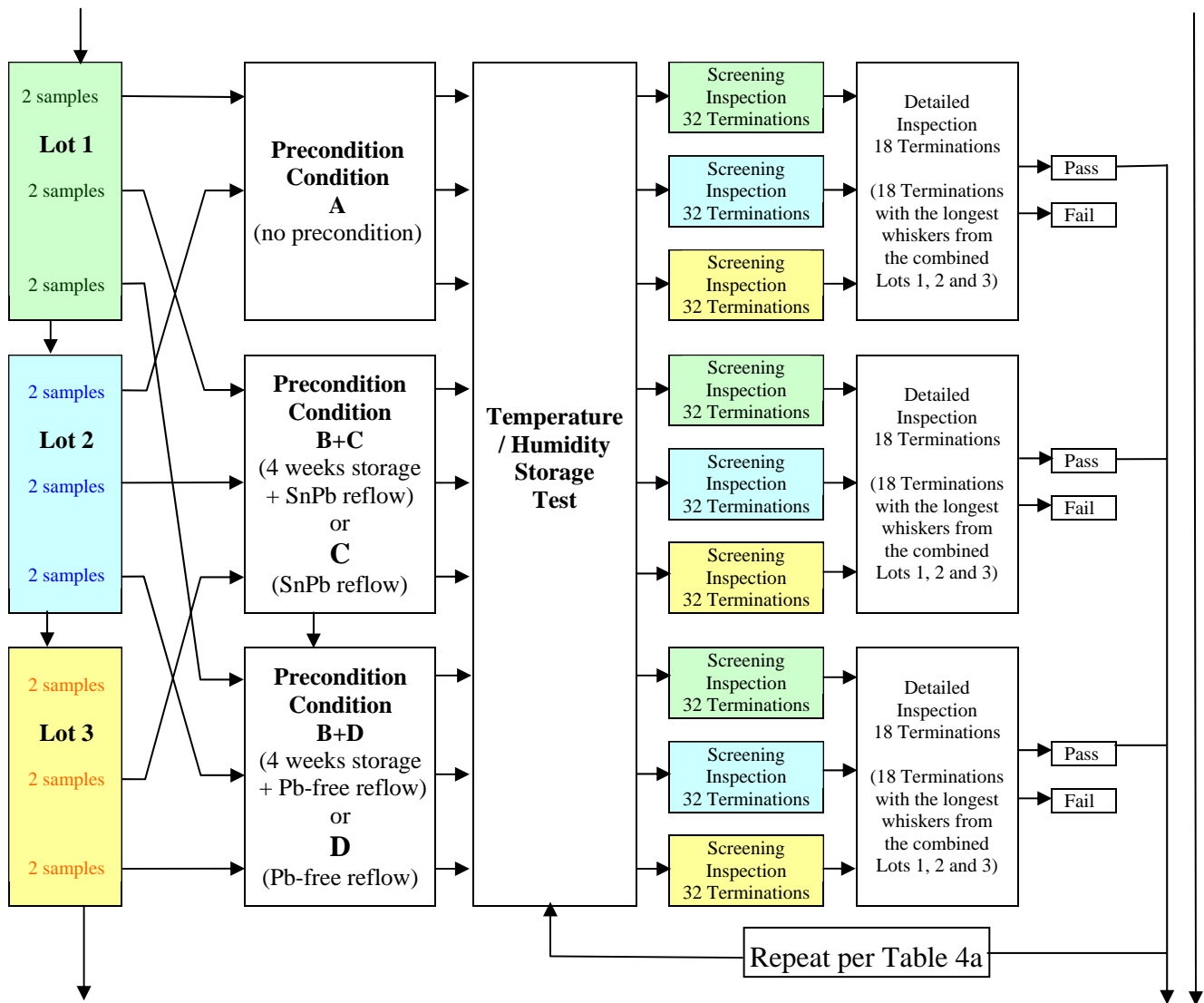


Matte Sn on Cu (Optical/SEM)

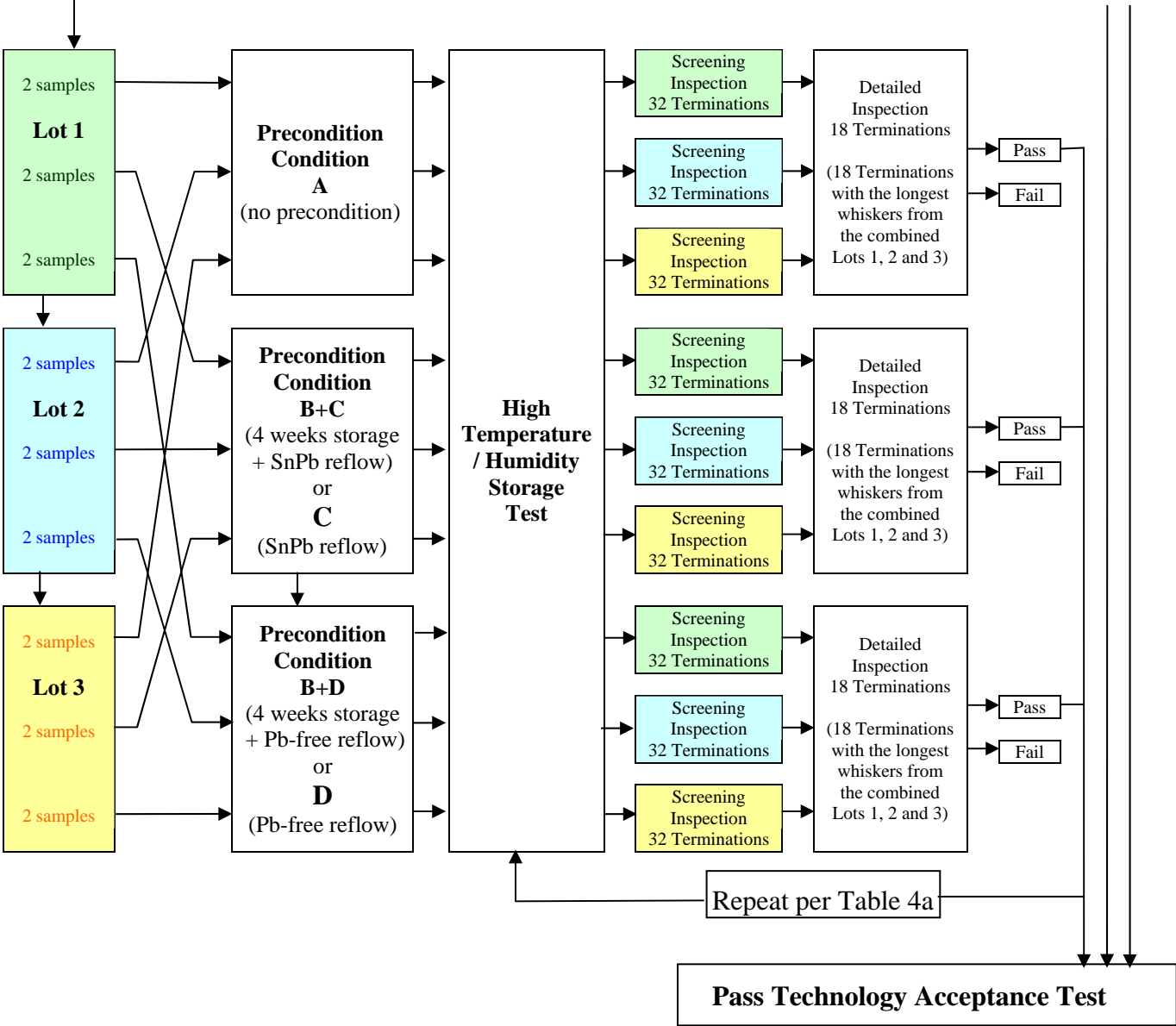
Annex B Technology Acceptance Test Flow for Multi-Leaded Components



Annex B Technology Acceptance Test Flow for Multi-Leaded Components (cont'd)



Annex B Technology Acceptance Test Flow for Multi-Leaded Components (cont'd)



Annex C Reflow assembly

The board assembly process shall reflect both the influence of typical reflow temperatures and the metallurgical effects of a typical solder material. Components for which the terminations are usually fully wetted, even with a board assembly process at the lower process window limits, are exempted from this test. For example, this applies to:

- nonleaded components
- flat leaded components.

Since whiskers usually grow only from the unwetted surface finish, it is essential that there is some unwetted area left after the board assembly process. This area shall represent at least 1/3 of the termination surface. Technical justification (documentation) shall be provided that the 1/3 minimum unwetted area requirement has been met, for example statistical EDX analysis, etc. The number of sample terminations inspected needs to be increased due to the reduction of termination area wetted by the board solder. The inspection increase should be based on achieving approximately the same area as an unwetted termination. For example, if only 1/3 of the termination area is unwetted, 3 times as many terminations must be inspected than for unassembled components, i.e. $96 \times 3 = 288$ per stress test.

The board assembly process will likely be somewhat different than typical production assembly processes because of the requirement for minimum termination wetting. In cases where the acceptance of multiple component types is being assessed by Similarity (Tables 1 and 2), it is recommended that board assembly be performed on the component type with the longest terminations in order to promote the presence of unwetted surface. The following table provides some further guidance for the board assembly process that may help to minimize termination wetting. Finally, it is recommended to clean the test board of flux residues before acceptance testing due to the unknown effect of flux residues on whisker growth.

SMT Board Assembly Process Guidance for Minimum Termination Wetting	
Reflow Atmosphere	Air
Flux Type	Low activity
Paste Alloy	Precondition C: SnPb Precondition D: SnAgCu
Stencil	Substantial cut backs from production opening and/or thickness may be required
Reflow Profile ¹	SnPb and Pb-free reflow profiles per JESD22A121 table 3 and figure 1
NOTE 1 In some cases it may be necessary to use a peak temperature at the low end of the range in order to avoid substantial wetting of the terminations.	
NOTE 2 Boards do not need to be electrically functional.	



STANDARD IMPROVEMENT FORM

JEDEC _____

The purpose of this form is to provide the Technical Committees of JEDEC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to JEDEC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

JEDEC
Attn: Publications Department
2500 Wilson Blvd. Suite 220
Arlington, VA 22201-3834

Fax: 703.907.7583

1. I recommend changes to the following:

Requirement, clause number _____

Test method number _____ Clause number _____

The referenced clause number has proven to be:

Unclear Too Rigid In Error

Other _____

2. Recommendations for correction:

3. Other suggestions for document improvement:

Submitted by

Name: _____

Phone: _____

Company: _____

E-mail: _____

Address: _____

City/State/Zip: _____

Date: _____

JEDEC