NEMI National Electronics Manufacturing Initiative, Inc.

NEMI Tin Whisker User Group

Tin Whisker Acceptance Test Requirements
(Updated July 28, 2004)

Joe Smetana, Alcatel, Chairman

The NEMI Tin Whisker User Group
Active Participants

Participant companies provide products in Automotive, Consumer, High-End Computing, Space, & Telecom Industries

• Joe Smetana	Alcatel - Chairman
• Rick Charbonneau	Formerly of Storage Tek
• Vicki Chin, Zequn Mei, Diana Chiang	Cisco
• Richard Coyle	Lucent - Co-Chairman
• George Galyon	IBM eSystems Group
• Ron Gedney	NEMI consultant
• Bob Hilty	Tyco Electronics
• John Lau	Agilent Technolgies
• Sean McDermott	Celestica
• Rich Parker	Delphi Electronics & Safety
• Frances Planinsek	Storage Tek
• Heidi Reynolds & David Love	Sun Microsystems
• Valeska Schroeder, Elizabeth Bennedeto	Hewlett Packard

Also

Nick Vo of Freescale represents the supplier point of view

Introduction

- **After >5 decades of research, a basic understanding of the mechanisms that control tin whisker growth and prevention is elusive**
- **Accelerated test conditions and the relationship to field conditions are not established**
- **In spite of this, the industry is moving towards Pb-free electronics**
- **Thus, there is a need for a specification combining tin whisker mitigation practices and acceptance testing to minimize the risk of tin whiskers**
- **This document provides the mitigation practices, test conditions and acceptance criteria for evaluating devices with a Sn (or high Sn alloy) finish**
- **It is expected to change as more data and perhaps technical understanding of whisker formation becomes available**

Background

- **Tin whiskers are a reliability concern. They can cause electrical shorts, disruption of moving parts, and/or degraded RF/High speed performance**
- **This document requires the use of the NEMI "Tin Whisker Growth Test" (available at www.nemi.org) (Future JEDEC spec)**
  - **Adds criteria to make this an acceptance test**
    - » **Test Durations**
    - » **Failure Criteria**
    - » **Sample Size**
    - » **Representative Preconditioning**
    - » **Limited Bias Testing**
- **This specification does not eliminate the chance of a whisker-related failure in service. However User Group members have accepted that following it will reduce the risk of tin whisker related problems**

All User Group Members have accepted this specification

Tin Whisker Mitigation Requirements

- **Components qualified and accepted by this testing <u>shall</u> utilize one of the preferred mitigation practices specified in "Tin Whiskers, NEMI Users Group Position statement" (available at www.nemi.org), briefly summarized:**
  - **Fusing by the component supplier of the tin plating within a short time frame after plating.**
  - **Use of a hot dip tin (or tin alloy) finish rather than plating.**
    - **Hot dip SnAgCu is the preferred alloy.**
  - **Use of nickel plated barrier layer between the base material and the tin**
  - **Annealing/heat treating (150°C for 1 hour) of a matte tin finish within a short time frame after plating (typically less than 24 hours).**
    - **Note: This mitigation practice may not be acceptable to all users.**
  - **Other acceptable mitigation practice as defined by the User Group Position Statement section III, paragraph 15**

Historical Data on Mitigation Practices

Mitigation Practice	Maximum Historical Data on Tin Whisker Length
Reflowed Tin	<100 µm
Hot Dipped Tin (or tin alloy)	<100 µm
Matte Tin over Nickel	<100 µm
Annealed Matte Tin over Copper	<100 µm
Matte Tin over Copper	800 µm

Test data shows significant variability in whisker performance for finishes with similar mitigation practices plated under different conditions.

Clarifies need for **both** a viable mitigation practice and testing of the finish

Exceptions to these Test Requirements

- **Users have long accepted & will continue to accept small discrete resistor and capacitor device components with a matte Sn over Ni finish**
  - **The devices must meet all the following criteria to be acceptable**
    - » **The Sn finish shall be matte tin**
    - » **The Ni under layer shall be at least 2µm (80 µinches)**
    - » **The supplier shall have data to substantiate control of his processes to minimize whisker growth (detailed later)**
    - » **The devices must not require any lead forming or other stress creating operations after final finish**
    - » **Tin plating thickness 2 µm (80 micro inches) minimum**
    - » **New component types must be similar in size and construction to previously accepted components**
    - » **Plating of new component types must use the same plating lines, chemistries, etc. that have been previously accepted**
    - » **New component types must also pass this test unless specified by the using company**

Overview of Testing

- **3 Test Segments: 2 isothermal and 1 Temperature Cycling of NEMI "Tin Whisker Growth Test" (Submitted to JEDEC)**
  - **Ambient/Storage (30ºC, 60% RH)–minimum* 4000 Hrs**
  - **Aging/Temperature & Humidity (60ºC, 93%RH)–minimum* 4000 Hrs**
  - **Thermal Cycling (-55ºC to + 85ºC)–minimum* 1000 cycles**
    - *** Test Durations may be longer depending on results (more later)**
- **Tests are extended to include assembly preconditioning and bias to represent actual use conditions**

Test Components

- **Components must be representative of the actual products that the finish to be tested shall be applied to**
  - **Can be qualified by “Like Construction” – as defined by Appendix A (discussed later)**
  - **Bias test (for technology qualification of the tin finish only) must use devices with the minimum lead-pitch to be qualified**
- **Plating Method**
  - **The plating method and supplier(s) used for plating shall be the production plating and supplier proposed for qualification**
  - **Each plating supplier shall be qualified separately**
    - » **More details as defined by Appendix A (discussed later)**

Sample Size – Test Components

Each lot - a different date code & plated at least one week apart

# Components (leads)/Lot (minimum)[1]	**# Lots**	**Precondition[3]**	**Test Condition**	**Total # Components (leads) (minimum)**
3 (30)	3	4 weeks @ room temperature (RT)	Storage – No Bias	9 (90)
3 (30)	3	4 weeks RT	Aging – No Bias	9 (90)
3 (30)	3	4 weeks RT, then Assembly Sim @ 215°C	Storage – No Bias	9 (90) [3]
3 (30)	3	4 weeks RT, then Reflow @ 255°C	Storage – No Bias	9 (90) [3]
3 (30)	3	4 weeks RT, then Assembly Sim @ 215°C	Aging – No Bias	9 (90) [3]
3 (30)	3	4 weeks RT, then Reflow @ 255°C	Aging – No Bias	9 (90) [3]
3 (30)	3	4 weeks RT, then Assembly Sim @ 215°C	Thermal Cycle – No Bias	9 (90)
3 (30)	3	4 weeks RT, then Reflow @ 255°C	Thermal Cycle – No Bias	9 (90) [3]
3 (30)	3	4 weeks RT, then Assembly @ 215°C	Storage – Bias	9 (90) [2] [3] [4]
			Total Components Required	**81 (810)**

Connect with and Strengthen your Supply Chain

Notes for Table 1 (previous slide)

(1) When number of leads per devices is less than 10, increase the minimum number of components in the sample size until the minimum number of leads (in parenthesis) is met

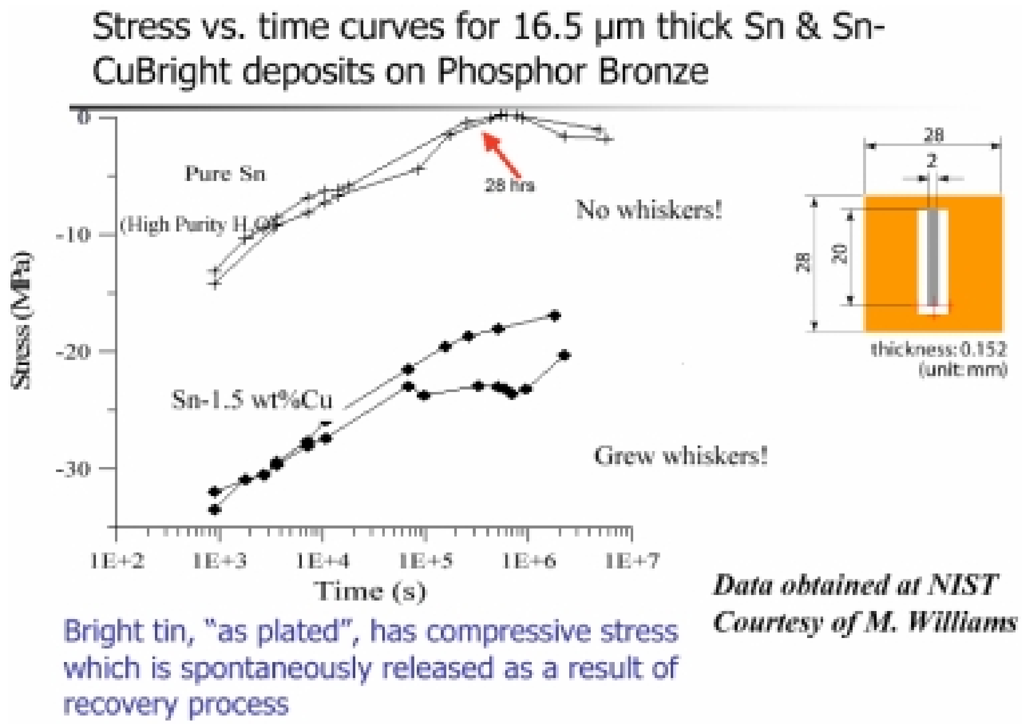
(2) Not required for 2-lead discrete components such as resistors and capacitors

(3) Not required when nickel under plating of the tin is the mitigation practice used except for compliant pin connectors.

(4) This test is for “technology qualification” and has reduced requirements. See paragraph 16.

Why 3 lots? Different Date Codes?

- **Process Repeatability is Critical**
  - **Control of impurities affects stress levels in the tin deposit**
    - » **+ Conflicting data on same finishes**
    - » **+ Conflicting data on same mitigation practices from different users**



Connect with and Strengthen your Supply Chain

Sample Size – Reference Components

# Components/ Lot	# Lots	Precondition	Test Condition	Total # Components (minimum)
1	1	None	Storage – No Bias	1
1	1	None	Aging – No Bias	1
1	1	None	Thermal Cycle – No Bias	1
			Total Components Required	**3**

Reference components are "optional". Use of them affects end-item requirements
Reference Components are components with the currently accepted finish
It contains a minimum of 2% of Pb

Calibration Specimens

- Required only for calibration of Optical Inspection methods (if SEM is not used)
  - 3 whisker specimens
    - 1@ <15 µm in length
    - 1@ 30-50 µm in length
    - 1@ > 60µm in length
  - Used to calibrate and confirm that optical inspection can consistently and accurately find and measure tin whisker length compared to SEM

Preconditioning Requirements (To address actual use conditions)

- None/4 week room Temperature Wait Period (see next slide)
  - Represents components in storage, prior to use
    - Note – No thermal cycle requirements when no-preconditioning as that is not representative of actual use (except for non-soldered components such as compliant pin)
  - Serves as a baseline reference for other tests
- Reflow Simulation @ 215°C* (1 reflow cycle)[1]
  - Represents components assembled with SnPb solder (backward compatibility)
    - Tested in all 3 test conditions
  - Lead-Free finishes do not reflow
- Reflow @ 255°C* (1 reflow cycle) [1]
  - Represents components assembled with SnAgCu solder (forward compatibility
    - Tested in all 3 test conditions
  - Lead-Free finishes are typically expected to reflow
- Assembly @ 215°C*
  - Limited to bias testing, ambient test condition only

[1]Agere's (and others) testing clearly shows results are different with different reflow temperatures

* Temperatures measured using thermocouples on the lead surface

Preconditioning (continued)

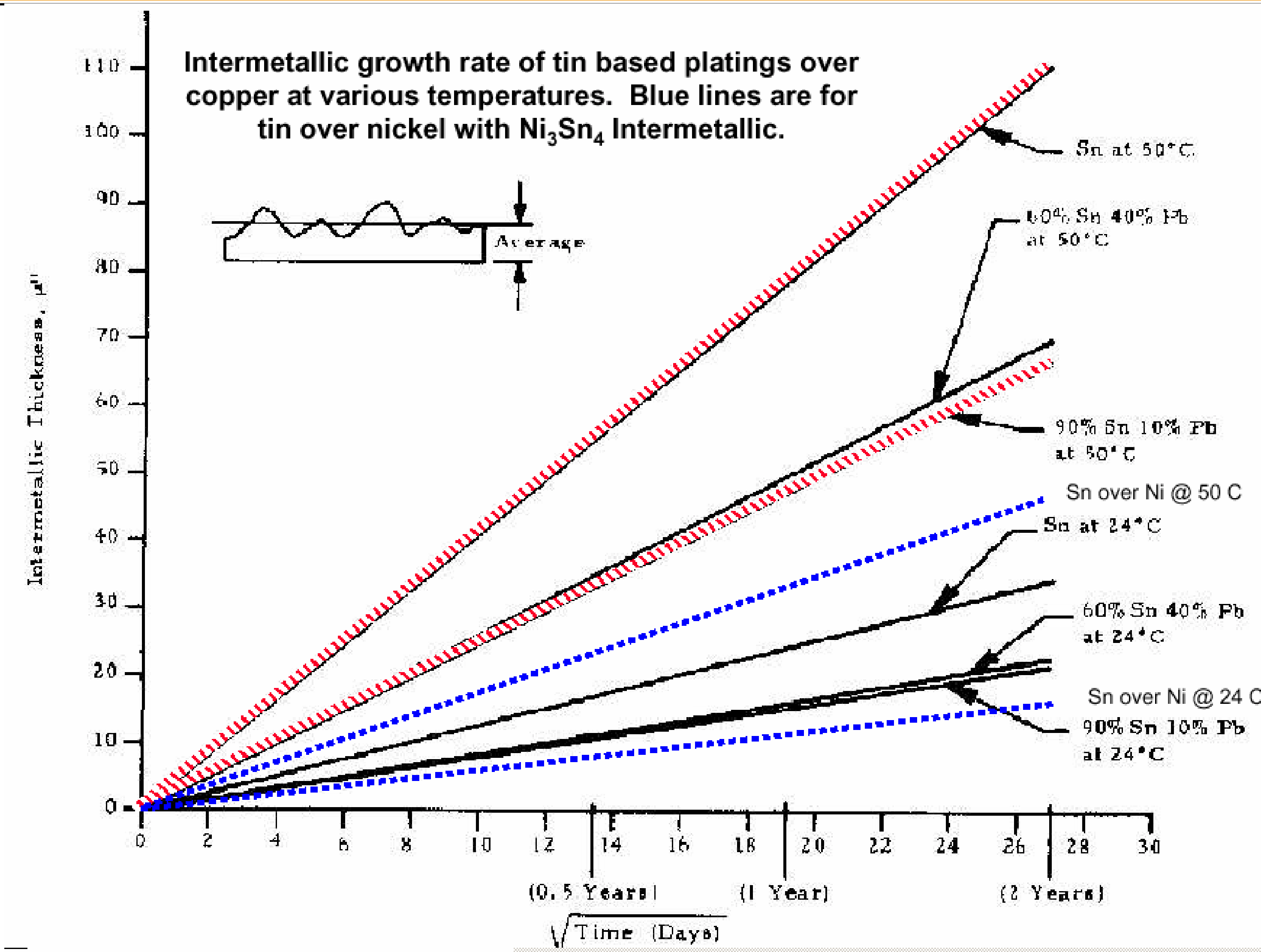
- “Wait Period” (4 weeks at Room Temperature)
  - Not required for devices with nickel under plating
  - Test and reference components shall not be preconditioned for a minimum of 4 weeks after finishing
    - » Allows the effect of intermetallic growth (such as Cu_6Sn_5) to be seen
      - May not be truly sufficient to get the full effect – however, 4 weeks was considered the maximum reasonable amount of time we could afford to wait – as test durations are already rather long
        - Intermetallic thickness grows at 1/2 power (square root) of time - thus the increase percentage wise in this thickness of the intermetallic:

From 1 week to 2 weeks - the increase is 41%
From 2 weeks to 3 weeks - the increase is 20%
From 3 weeks to 4 weeks - the increase is 17%

We Drew the Line Here

From 4 weeks to 5 weeks - the increase is 12%
From 5 weeks to 6 weeks - the increase is 9.6%
From 6 weeks to 7 weeks - the increase is 8%

Intermetallic Growth Rate of Tin Based Platings (Square Root of Time)



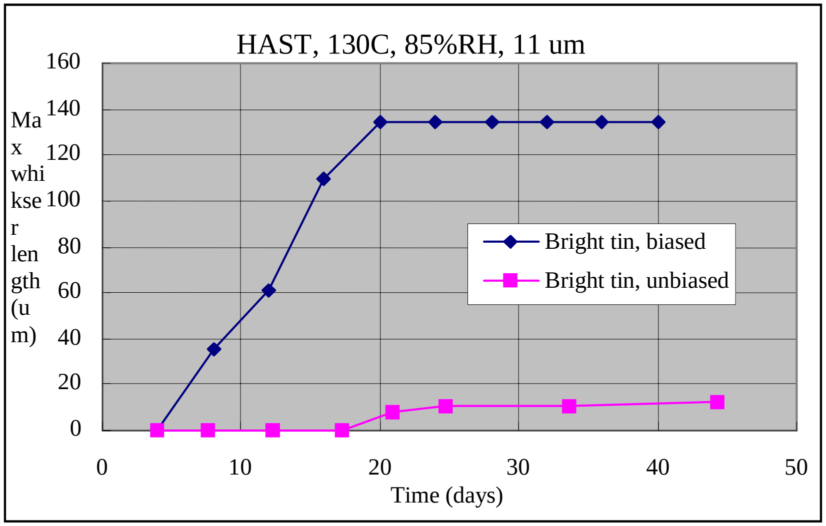
"Data obtained at Tyco Electronics/AMP by J. Haimovich"

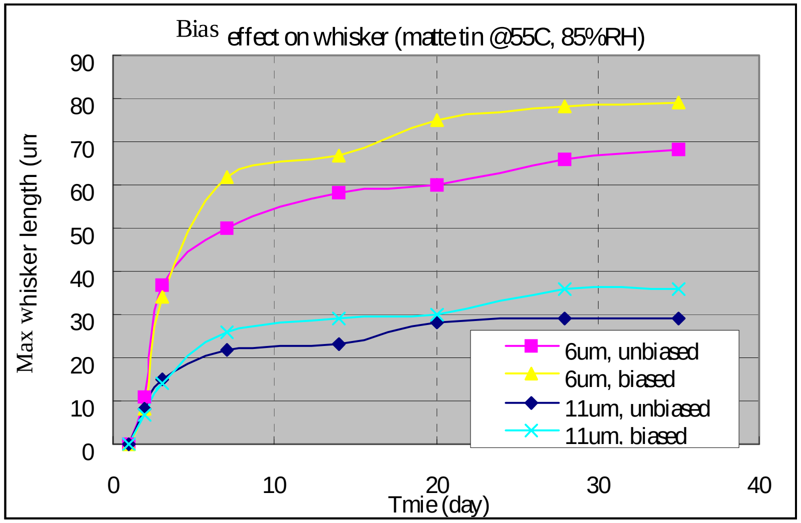
Agere's Data Supports Multiple Reflow Preconditioning Requirements

Material	Bake	T_{reflow}	RT Storage time = 56days	-55C/+85C T/C 2000 cycles	60C/93%RH Storage time =68days	60C/93%RH Bias (3.3 & 5 V) time =68days
Cu/Sn/1.5	no	no	whiskers	whiskers	whiskers	--------------
Cu/Sn/1.5	yes	no	whiskers	whiskers	whiskers	--------------
Cu/Sn/15	no	no	No whiskers	No whiskers	No whiskers	No whiskers
Cu/Sn/15	yes	no	No whiskers	No whiskers	No whiskers	No whiskers
Cu/Sn/15	yes	215C	No whiskers	whiskers	No whiskers	No whiskers
Cu/Sn/15	yes	260C	No whiskers	No whiskers	whiskers	whiskers
Cu/Ni/Sn/1.5	no	no	No whiskers	whiskers	No whiskers	No whiskers
Cu/Ni/Sn/1.5	yes	no	No whiskers	whiskers	No whiskers	No whiskers
Cu/Ni/Sn/15	no	no	No whiskers	whiskers	No whiskers	No whiskers
Cu/Ni/Sn/15	no	215	No whiskers	whiskers	No whiskers	No whiskers
Cu/Ni/Sn/15	no	260	No whiskers	No whiskers	No whiskers	No whiskers
Cu/Ni/Sn/15	yes	no	No whiskers	whiskers	No whiskers	No whiskers
Cu/Ni/Sn/15	yes	215	No whiskers	whiskers	No whiskers	No whiskers
Cu/Ni/Sn/15	yes	260	No whiskers	No whiskers	No whiskers	No whiskers

Bias Testing

- **Bias effect on Tin Whisker Growth appears to be finish dependent**
  - **Our primary goal is to test whether or not whisker growth on the finish being qualified is affected by bias or not.**
  - **As such we've limited the testing to ambient samples only.**
  - **Examples: #1 Phillips data**



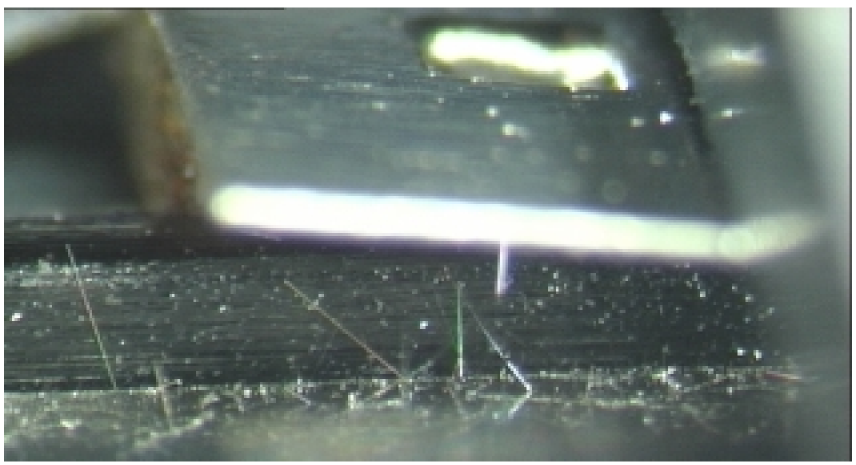


Clear effect on Bright Tin, Matte Tin Data not conclusive

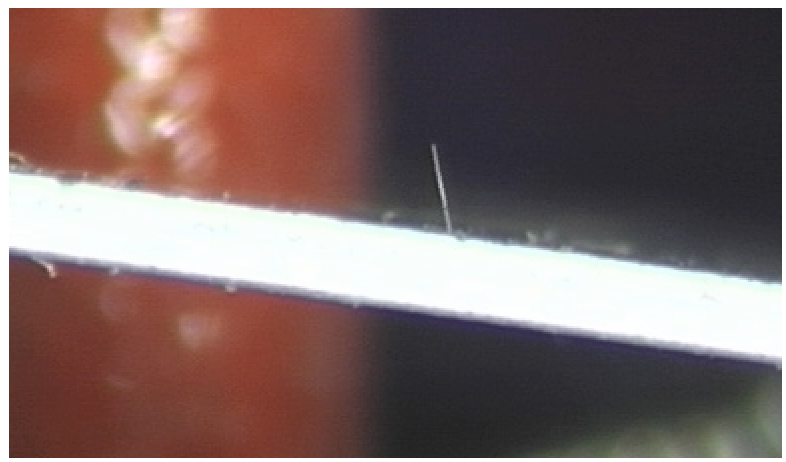
(Philips statement: "no effect")

Bias Testing (continued)

- **Example 2: TI Application Report SZZA037 - January 2003 (Tests on Matte Tin)**
  - **"we found whiskers quite consistently on the biased samples, but not on the parallel run of parts with no bias"**
- **Example 3: Alcatel Field Failure on Bright Tin Plated Breaker (50V Bias) (Tin should have been reflowed – but was not)**



Whiskers in Bias Area – Dense and 2-5 mm long!

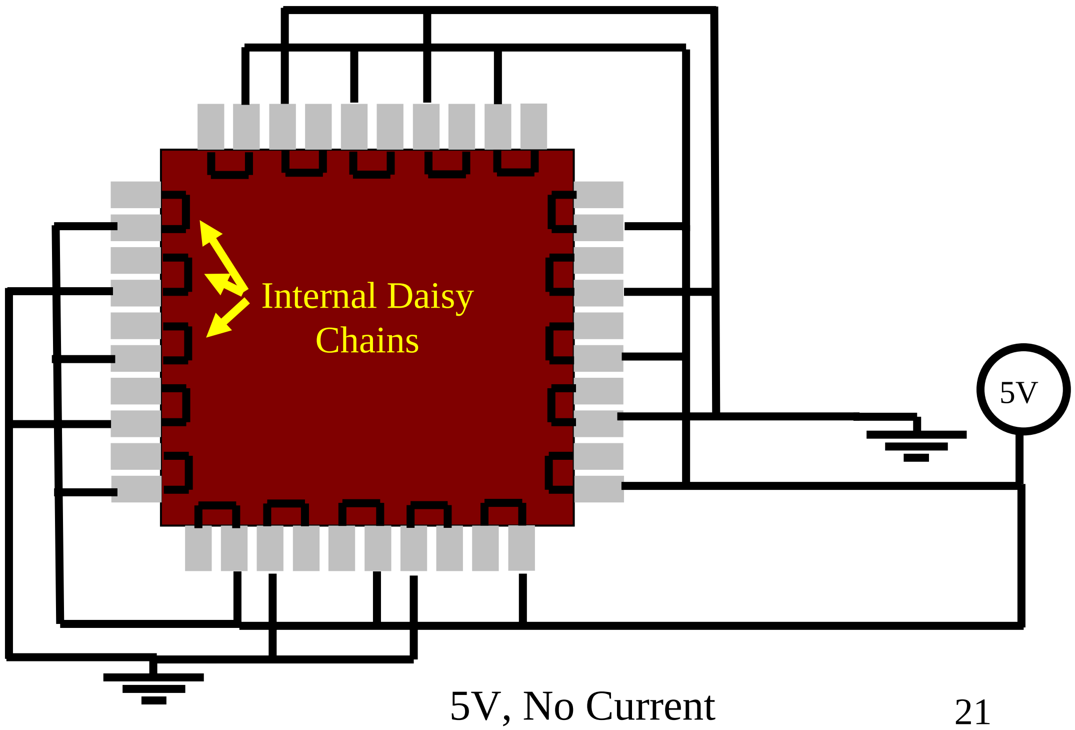


Whiskers away from Bias Area – Much Fewer and a max of about 1mm long

Bias Testing (continued)

- Test only the minimum lead-pitch to be qualified
- May be done in a socket if supplier can assure validity
- 5V Bias between adjacent leads
  - At least ½ the leads on device should be biased
  - Minimum of 3 pairs of leads (per lot sample) even if this increases total number of components

Example of QFP Schematic using Daisy Chain Device



Inspection Requirements

- **Prescreen required for the presence of whiskers (optical microscope or SEM)**
  - **Detailed evaluation of the whisker length of representative areas containing the longest whiskers, based on this prescreening, shall be done per the methods of the NEMI "Tin Whisker Growth Test"**
- **Inspection and reporting per the methods of the NEMI "Tin Whisker Growth Test"**
  - **Exception – Bias Test Read point only required at 4000 hours**
    - » **Bias Test only need continue beyond this if whiskers are found longer than same test without bias**
  - **Our read points are at 1000 hours intervals → looking for saturation (1500 hours intervals would extend the test)**
  - **At supplier's option, whisker inspections may be delayed until after completion of the minimum 1000 thermal cycles or 4000 hours (and not done periodically during the testing).**
    - » **This may increase the test times as whisker length may saturate prior to these intervals being met**

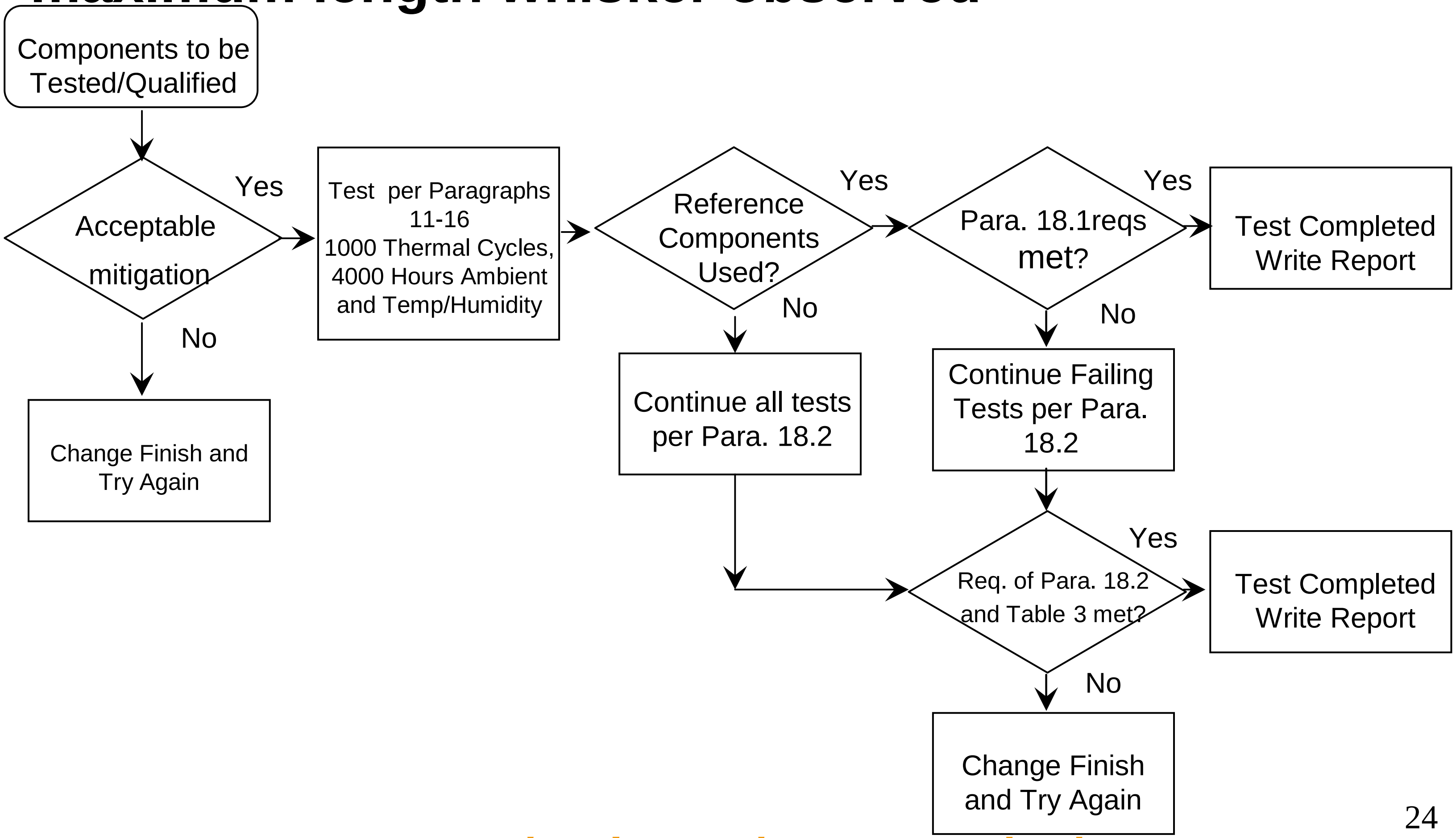
Note – Users prefer SEM

Optical Inspection Calibration/Qualification (Only required if SEM is not used)

- **One time qualification of the inspection technique**
  - **Measurement technique studied and compared to SEM**
    - » **Minimum of 5 whiskers – baseline measured using SEM**
      - **1@ <15 μm in length**
      - **3@ 30-50 μm in length**
      - **1@ > 60μm in length**
    - » **Same whiskers inspected optically**
      - **Optical measurements repeated a minimum of 3 times**
        - **A complete setup of the optical microscope/measuring equipment**
        - **When multiple inspectors are used for optical inspection, this variation shall be included in the repetitions.**
      - **The accuracy and repeatability of the optical measurements shall be within 5μm of the SEM measurements at the +/-3 sigma limits**

Acceptance Requirements

- **Whisker acceptance requirements are based on the maximum length whisker observed**



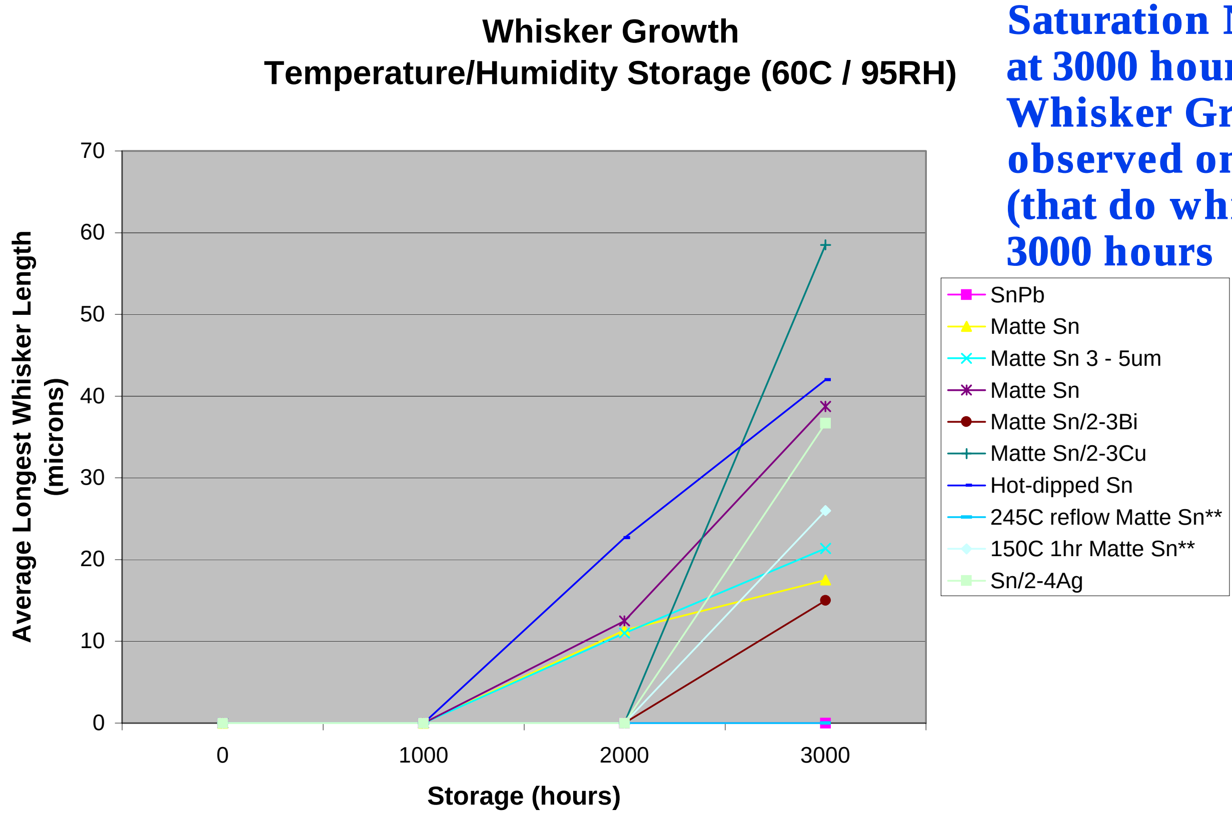
Acceptance Requirements (continued)

- **Tested Finish after 1000 T/C, 4000 Hours Storage (Ambient), 4000 Hours Aging (Temp/Humidity)**
  - **Whisker Length = SnPb Reference (or better)**
    - » **Done – Tests pass**
  - **If any tests fail to = SnPb Reference or if SnPb Reference components not used, must be continued (failing tests only)**
    - » **T/C test – minimum of 2000 cycles or 3 consecutive measurements at 500 cycle intervals show no growth**
    - » **Storage and/or Aging test – minimum of 5000 hours or 3 consecutive measurements at 1000 hour intervals show no growth**
      - **If you can't inspect the same whiskers – increase the sample sizes to show statistical significance!**
    - » **Must meet the Maximum Whisker Length Requirements - following**

End Point Determination

- **Minimum # hours (4000) (T/H and Ambient)**
  - **Ensuring that the "incubation period" for tin whisker growth has passed**
    - » **Data clearly supports that this is at least 3000 hours**
      - **Example: NEMI Whisker Test Group DOE3 data clearly supports this assertion**
        - **Very Few whiskers at 2000 hours – many at 3000 hours**
        - **For some finishes, only a few parts have had whiskers at the 3000 hour point – showing the need to go longer**
    - » **User Consensus reached that 4000 hours minimum was both necessary and acceptable**
- **Minimum # Thermal Cycles (1000)**
  - **NEMI DOE3 shows most significant whisker growth occurring between 0 and 1000 thermal cycles**
    - » **One finish (SnAg) showed no growth at 500 thermal cycles but did at 1000 Thermal Cycles**

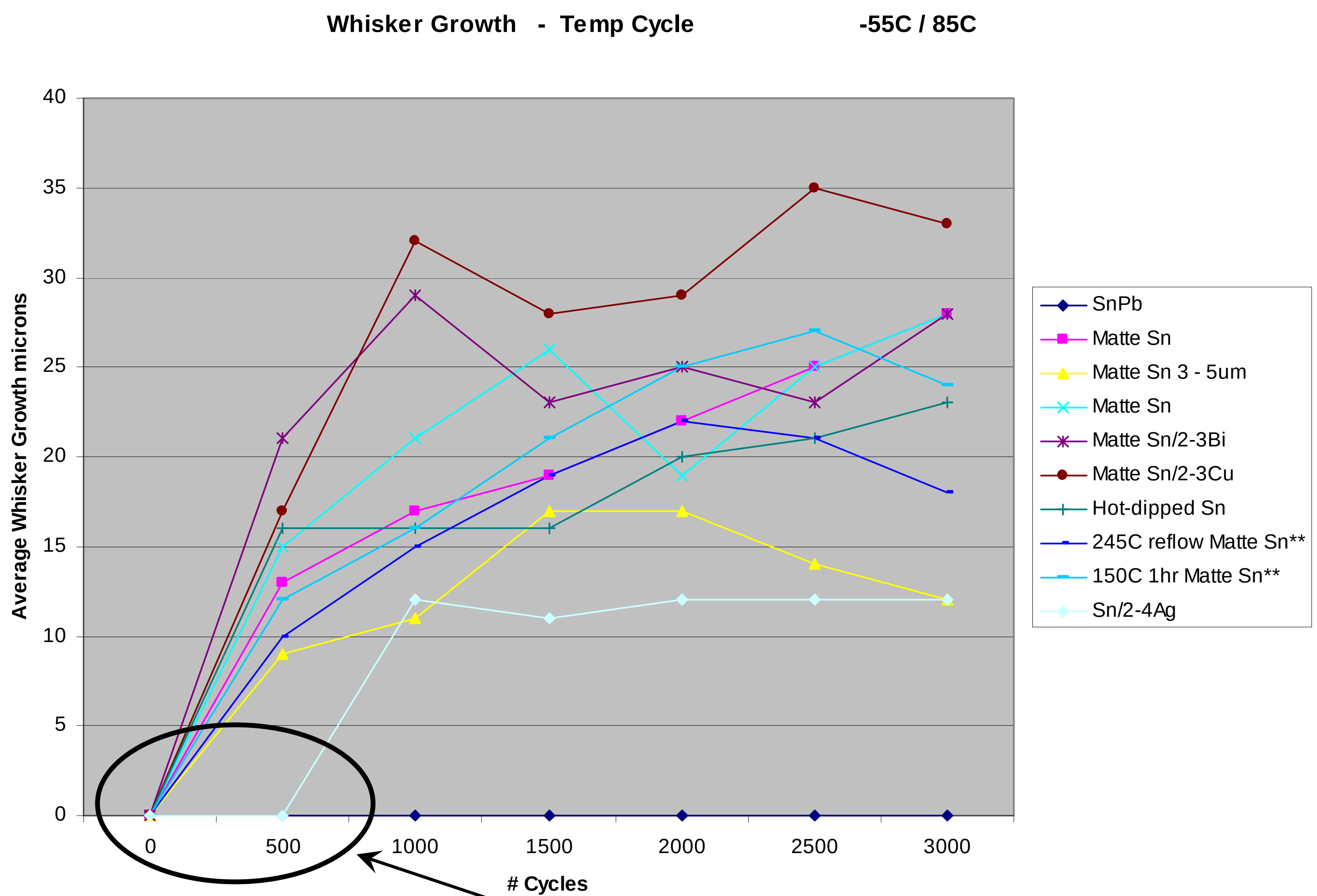
NEMI DOE3 – Isothermal Storage Results



Saturation Not Reached at 3000 hours
Whisker Growth not observed on all units (that do whisker) at 3000 hours

- Whiskers formed as soon as 2000hours
- Different incubation periods for each finish
- Corrosion products is observed at 3000hours for some cells
- Not all leads whisker (such as the case with SnAg)

Temp Cycle Data (NEMI DOE 3)



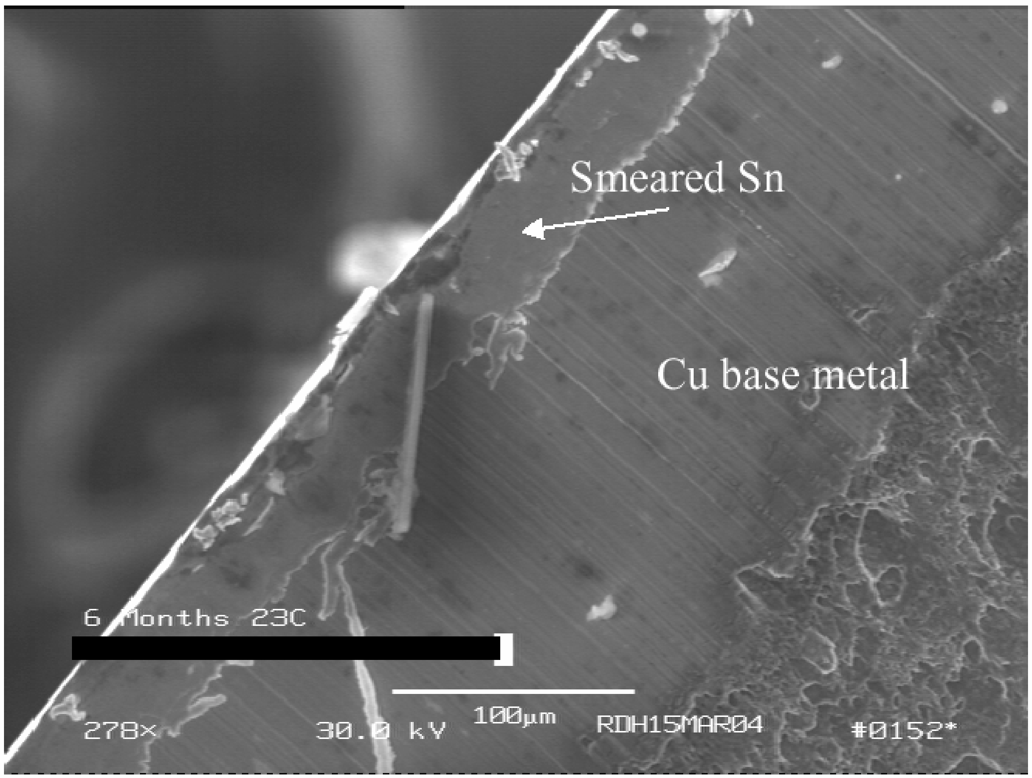
Note: No growth until >500 cycles

Whisker Length Limits

<table>
<tr><th colspan="4">Maximum Whisker Length</th></tr>
<tr><th>Device Considerations
(Package type, lead pitch or operating frequency)</th><th>Class 1</th><th>Class 2</th><th>Class 3</th></tr>
<tr><td>Discrete Device (2 pins)</td><td rowspan="3">Pure tin and high tin content alloys not acceptable.</td><td rowspan="3">40 µm</td><td>67 µm (1)</td></tr>
<tr><td>Multi-lead packages</td><td>(Minimum gap between leads - .05mm)/3 or 67 µm, whichever is smaller(1)(2)(3)</td></tr>
<tr><td>Operating Frequency > 6GHz (RF)(4) or t_{rise} < 59 psec (digital)</td><td>50 µm</td></tr>
</table>

(1) Often must also meet high frequency / high speed requirements
(2) Spacing does not account for dam bar protrusion, a risk area
(3) Accounts for up to 0.05mm bent leads. Max of 67µm accounts for adjacent discrete devices.
(4) Degradation associated with tin whiskers increases with frequency. The maximum frequency analyzed was 20GHz.

Dam Bar Protrusion – A risk Area



Tin smeared over the edge of a copper substrate during a trim operation. One 100 um long whisker seen in center. This is a bright tin deposit, exposed to 6 months at room temp under stress.

(Image Courtesy of Tyco)

The smeared tin is very thin and typically under stress.

If we account for dam bar minimum spacing our max whisker length would have to be reduced to 18um (Class 2) or 24 um (Class 3)

Class Definitions

- **The company purchasing components will classify its products. Below are general guidelines for product classes. However, these guidelines may not apply in all cases.**
  - **Class 1**
    - » **Mission/Life Critical High Reliability Applications such as military, space and medical applications**
      - **Pure tin and high tin content alloys not acceptable**
  - **Class 2**
    - » **High Reliability Business Applications such as Telecom Infrastructure equipment, High-end Servers, etc.**
      - **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 3**
    - » **Consumer Products**
      - **Short product lifetimes.**
      - **No major concerns with tin whiskers breaking off**

Determination of End Item Requirements (Appendix B)

- **Four Major Questions to Answer**
  - What is the maximum whisker length we can allow without a short?
  - What happens if a tin whisker breaks off? Where does it go?
  - What is the maximum whisker length that can be allowed without an adverse affect on RF/High speed performance?
  - What are the sources of error in the testing and what safety factor is required to accommodate for these sources of error in setting final length requirements?

Max Length Without a Short Circuit

- **Worst case, this is equal to ½ the distance from a lead to another lead or lead on another component or 1X the distance to the nearest trace on the PCB.**
  - **An excerpt from the Appendix B table:**

Device Pitch	Typical Minimum gap between leads(1)	Maximum allowable whisker length in application (=1/2 min typical gap)	Maximum allowable whisker length in testing (safety factor = 2/3 maximum distance)	Maximum allowable whisker length in testing (safety factor = ½ maximum distance)
Discrete Device (2 pin)	200 µm	100 µm	67 µm	50 µm
0.65 mm to < 1.27 mm	150-200 µm (2) (JEDEC MS-204)	75 – 100 µm	51 – 67 µm	38-50 µm
0.5mm to < 0.65 mm	125–150 µm (2) (JEDEC MS-204)	63 -75 µm	42-51 µm	32-38 µm
0.4mm to < 0.5mm	120 µm (2) (JEDEC MO-194B)	60 µm	40 µm	30 µm

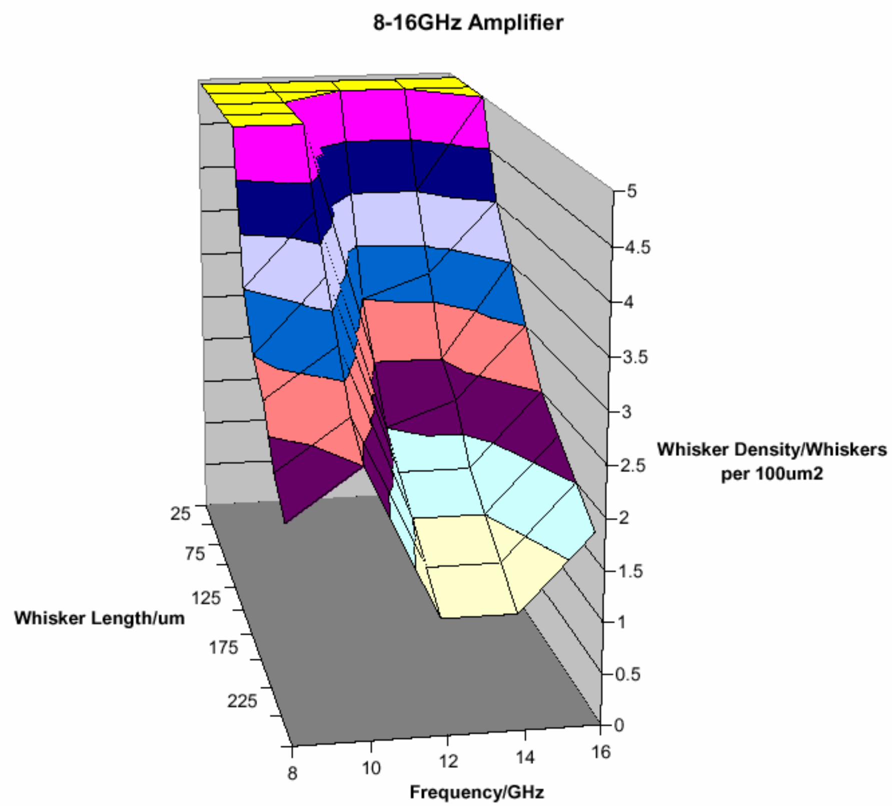
Below our requirements…

If a Whisker Breaks Off

- **Where does it go?**
- **What damage can it cause?**
- **This is a product specific concern**
  - **Disk drives are a typical concern, where even very small whiskers can cause failures**
    - **This is a component of many higher end systems**
  - **Longer whiskers may lodge elsewhere and cause shorts or reduced spacing in high(er) voltage systems**
    - **Example: power supply applications**
    - **May reduce spacing below minimum creepage and clearance requirements (see UL 60950 or IEC equivalent)**
  - **Concerns with lightning surge requirements are significant**
    - **This is true even when whiskers don't break off…**

Max whisker length without effect on RF/High speed performance

- **Modeled by Alcatel's Microwave Group**
  - **A complex function whisker length, whisker density, and frequency**
    - » **Modeled in various different configurations**
  - **The adverse affect starts at 6 GHz RF or t_{rise} of 58 psecs (or less) in a digital circuit**



Sources of Error

- **Sample size related – Are whiskers identified truly representative of the longest whisker?**
  - **Alternative - A much larger sample size combined with statistical analysis**
  - **Dramatically increase the effort and the cost of doing the testing.**
- **The measuring accuracy of the SEM/Optical analysis.**
- **Angle of the whisker relative to the measurement direction in the SEM/Optical Microscope when attempting to determine its length**
- **Fundamentals of whisker growth are unknown**
  - **No way to ensure that these tests reflect long field life requirements**
- **Tests drive whisker growth to saturation:**
  - **Measurement inaccuracy prevents ensuring growth has truly stopped**
  - **Unknown if saturation will actually occur in field conditions**
- **The tests as defined do not account for any possible damage to the components such as scratches in the finish that might exacerbate tin whisker growth.**

Safety Factor

- Based on all the previous, the User Group chose the following safety factors for test data relative to field data
  - Class 3: Maximum allowed whisker = 2/3 Worst case situation
  - Class 2: Maximum allowed whisker = ½ Worst case situation
    - » Note – rounded up from 37.5 to 40µm for ½ RF concerns
    - » Also compromised on 0.4 mm pitch devices

Qualification Test Report

- Users require a thorough qualification report that will readily enable us to evaluate any whisker test data to our requirements. Includes (but not necessarily limited to):
  - Plating facility, line, chemistry, etc. as defined by Appendix A
  - Component package type, under layer plating (if any), and lead frame base material(s)
  - Plating and under layer plating (if any) thicknesses
  - Date of plating of each lot and lot identification
  - Tin and under layer plating requirements of reference 3.2 Appendix B
  - Preconditioning reflow profile details
  - Date of preconditioning
  - Bias Test board description
  - Sample sizes
  - Inspection equipment details including SEM make and model and magnifications used.
  - Optical Inspection Qualification, if applicable
  - Whisker length results for each test graphed a the specified intervals
  - A summary of the test results versus the requirements of this specification. Each test condition, including the preconditioning and bias requirements as applicable shall be addressed. Sufficient data, such as graphs, SEM photographs, etc. shall be provided such that user acceptance can be <u>clearly determined</u> per the requirements of this specification.

Process Controls and Periodic Testing

- **We are convinced that repeatability of the process is one of the key items that affect tin whisker propensity of a finish**
  - **Suppliers must define and maintain plating process controls**
  - **Some specifics that Users require**
    - » **Carbon content shall be kept below 0.05%**
    - » **Copper content (except for SnCu alloys) should be kept below 0.5%**
  - **Characteristics of the tin plating shall also be determined and controlled**

Ongoing Tin Whisker Monitoring

- **Supplier will establish a system to periodically monitor the performance of the 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 should be taken for each designated time period**
  - **The time period for these samples should be at least monthly**
  - **The storage conditions for these components should include a relative humidity of 60% or greater. Using the ambient test conditions of reference 3.2 (Tin Whisker Test) 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.**

Whisker Test by Similarity Determination Matrix

	Example/Notes	Separate Whisker Test Required?
Assembly Process (1)	Different Trim and Form methods	Yes
Lead Form	For IC packages: 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. For connectors or other packages: Select the product for testing that has the most extreme case of tin deformation due to trim and form operations	Select per Notes column
Lead Dimension	0.25mm wide, 0.18mm wide…	No
Pin Count	52, 64, 80…	No
Basis Materials(2) (Leadframe Material/Under plating)	The material directly under the tin. Cu alloy C19400 (CuFe2), C70250 (CuNiSi), Alloy42 (FeNi42), Ni barrier plating	Yes
Finish Alloy	Sn, Sn/3.5Ag, Sn/3.0Bi, Sn/1.0Cu, Sn/3.0Cu…	Yes
Bath Chemistry	Supplier A, XXX; Supplier A, YYY; Supplier B, ZZZ…	Yes
Plating Process (3) or Dip Process(4)	High speed reel to reel, High speed belt, Low speed rack/barrel/cassette or Jet plating. Agitation, Current density, Bath Temperature…	Yes
Equipment	Supplier A; Supplier B…	No
Factory	Factory A, Factory B…	Yes
Plating Line	Line 1, Line 2… in same or different factory (provided process is the same per above)	No

Notes for Similarity Determination Matrix

(1) If post finishing assembly processes (typically trim and form) can be shown to be essentially identical where the mechanical and thermal stresses added to the component are similar, then one set of tests can be done to address them all.

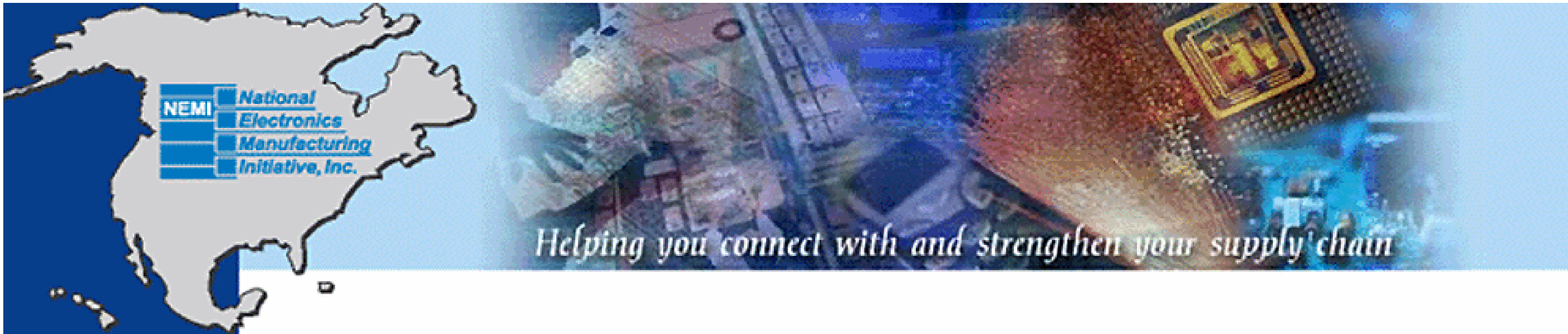
(2) If a nickel barrier is used, then a change to the copper alloy under the nickel does not necessitate a new whisker qualification

(3) The plating process includes variables suspected to affect whisker growth such as agitation, additive levels, metal content, acid content, temperature, current density, impurity levels. These factors should be evaluated to the edges of the acceptable process control window to ensure whisker control over the entire process spectrum. These can be evaluated through a design of experiments approach and tested to the conditions outlined in this document. If the supplier cannot test qualification samples to the edge of the process window, then any changes to the plating process (e.g., current density, agitation, etc.) will require re-qualification.

(4) Changes in solder dipping processes would include items such as, but not necessarily limited to, flux or any other chemistry change that would affect impurity levels or content in the solder dip baths, immersion rate, cooling rate, or any other variable that is suspected to affect tin whisker growth.

Summary

- Tin Whisker Growth is a complex issue where the fundamentals are not understood
- The Mitigation and Test requirements reflect that complexity
  - The testing is unfortunately rather extensive and over a long duration
  - We've done what we believe is reasonable to reduce this complexity and still have confidence in the results
  - The requirements have been significantly reduced based on supplier feedback from the 2004 ECTC User-Supplier Forum
  - When we learn more, we'll readily revise the test requirements
- All User Group companies will accept components that meet these requirements
  - Other companies are already also coming on board (Tellabs, Bosch)
- Our belief is that virtually every end user would accept qualification to this document (They would define the Class)
  - Meets a major industry need for 1 test/acceptance requirement
- We believe component suppliers should adopt these requirements
  - "The customer is always right"



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