Specification for Procurement of Lead (Pb)-Free Electronic and Electromechanical Components and Assemblies

ABOUT FLEX

Flex is a leading sketch-to-scale™ solutions company that designs and builds intelligent products for a connected world. With more than 200,000 professionals across 30 countries and a promise to help make the world Live smarter™, the company provides innovative design, engineering, manufacturing, real-time supply chain insight and logistics services to companies of all sizes in various industries and end-markets. For more information, visit www.flex.com or follow us on Twitter@Flex.

1.0 BACKGROUND/INTRODUCTION

1.1. Environmental legislation in Europe and other parts of the world have banned the use of Lead (Pb) in electronics products effective July 1, 2006. Our customer's requirements dictate that we design and manufacture products that conform to the Lead-free environmental regulations. Therefore, we need to ensure that our supply chain is prepared to meet all requirements necessary to comply with the legislation.

1.2. This document is subject to change with respect to technological and legislative changes relating to Lead-free solder and parts.

2.0 PURPOSE

2.1. This document provides the requirements to all flex procurement groups and component suppliers regarding procurement of Lead (Pb)–free electronic components and assemblies. The purpose of this specification is to ensure that all electronics components and/or assemblies will support flex assembly process capabilities necessary to manufacture Lead-free products.

3.0 SCOPE

3.1. All electronic components or assemblies that flex requires to be Lead-free, shall meet the requirements set forth in this document.

4.0 DEFINITIONS and ABBREVIATIONS

4.1. Lead-free: A Lead-free component is defined as its Lead content < 0.1% or 1000ppm (by weight, per homogeneous material) based on the European Restriction on Hazardous Substances (RoHS).

4.2. Lead-free solder alloy: The Lead content must be less than 0.1% (1000ppm) Lead (Pb) by weight

4.3. Matte tin (Sn): A tin film with lower internal stresses and larger grain sizes typically of 1µm or greater and carbon content less than 0.050%

4.4. Bright tin (Sn): A tin film with higher internal stresses and smaller grain size of 0.5 µm to 0.8 µm and carbon content of 0.2% to 1.0%

4.5. Backward compatibility: Components can be soldered using existing Sn-Pb solder and temperature profiles

4.6. Forward compatibility: Components can be soldered using Lead-free solders and the appropriate higher temperature profiles

4.7. PCN: Product Change Notification

4.8. SMD: Surface Mount Device

4.9. SMT: Surface Mount Technology

4.10. CoC: Certificate of Compliance

4.11. RoHS: Restriction of Hazardous Substances

4.12. MSL: Moisture Sensitivity Level

4.13. EOL: End Of Life

4.14. IST: Interconnect Stress Testing

5.0 REFERENCES

5.1.

Document Title	Document Number	Document \ Hyperlink
Solderability Tests for Printed Boards	IPC J-STD-003	www.ipc.org
Generic Performance Specification for Printed Boards (as applicable to product offering)	IPC-6011	www.ipc.org
Qualification and Performance Specification for Rigid Printed Boards	IPC-6012	www.ipc.org
Qualification and Performance of Permanent Polymer Coating (Solder Mask) for Printed Boards	IPC-SM-840	www.ipc.org
Acceptability of Printed Boards	IPC-A-600	www.ipc.org
Generic Standard on Printed Board Design	IPC-2221	www.ipc.org
Test Methods Manual Section 2 “Time to Delamination (TMA Method)” 288ºC recommended for Method 2.4.24.1	IPC-TM-650	www.ipc.org
Test for Flammability of Plastic Materials for Parts in Devices and Appliances	UL 94	www.ul.com
Packaging and Handling of Moisture Sensitive Non-Hermetic Solid State Surface Mount Devices	IPC/JEDEC J-STD-033	www.ipc.org www.jedec.org
Solderability Tests for Component Leads Terminations, Lugs, Terminals and Wires	IPC/ECA J-STD-002	www.ipc.org www.ec-central.org
Qualification and Performance Test Methods for Surface Mount Solder Attachments	IPC-9701	www.ipc.org
Stress Qualification for Integrated Circuits	AEC-Q100	www.aecouncil.org
High Temperature Storage Life	JESD22-A103	www.jedec.org
Current Tin Whiskers Theory and Mitigation Practices Guideline	JEDEC/IPC JP002	www.ipc.org www.jedec.org
Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes	JESD22-A121	www.jedec.org
Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes	JESD201	www.jedec.org
Moisture/Reflow Sensitivity Classification of Plastic Surface Mount Devices	IPC/JEDEC J-STD-020	www.ipc.org www.jedec.org
Test Method Standard Electronic And Electrical Component Parts	MIL-STD-202	www.dscc.dla.mil
Marking and Labeling of Components, PCBs and PCBAs to Identify Lead (Pb), Pb-Free and Other Attributes	IPC/JEDEC J-STD-609	www.ipc.org www.jedec.org
Flex Specification of Banned and Restricted Substances for Use	CES-REG-1-001-00	Flex document. Contact flex.
Generic Reliability Assurance Requirements for Optoelectronic Devices Used in Telecommunications Equipment	Telcordia GR-468	www.telecom-info.telcordia.com
Guidelines for User Notification of Product/Process Changes by Semiconductor Suppliers	JESD46	www.jedec.org
Product Discontinuation	JESD48	www.jedec.org

Flex Supplier Portal		https://flex.com/supplier-information

6.0 POLICY STATEMENT

6.1. It is flex's policy to procure environmental compliant and friendly materials.

7.0 PROCESS FLOW CHART

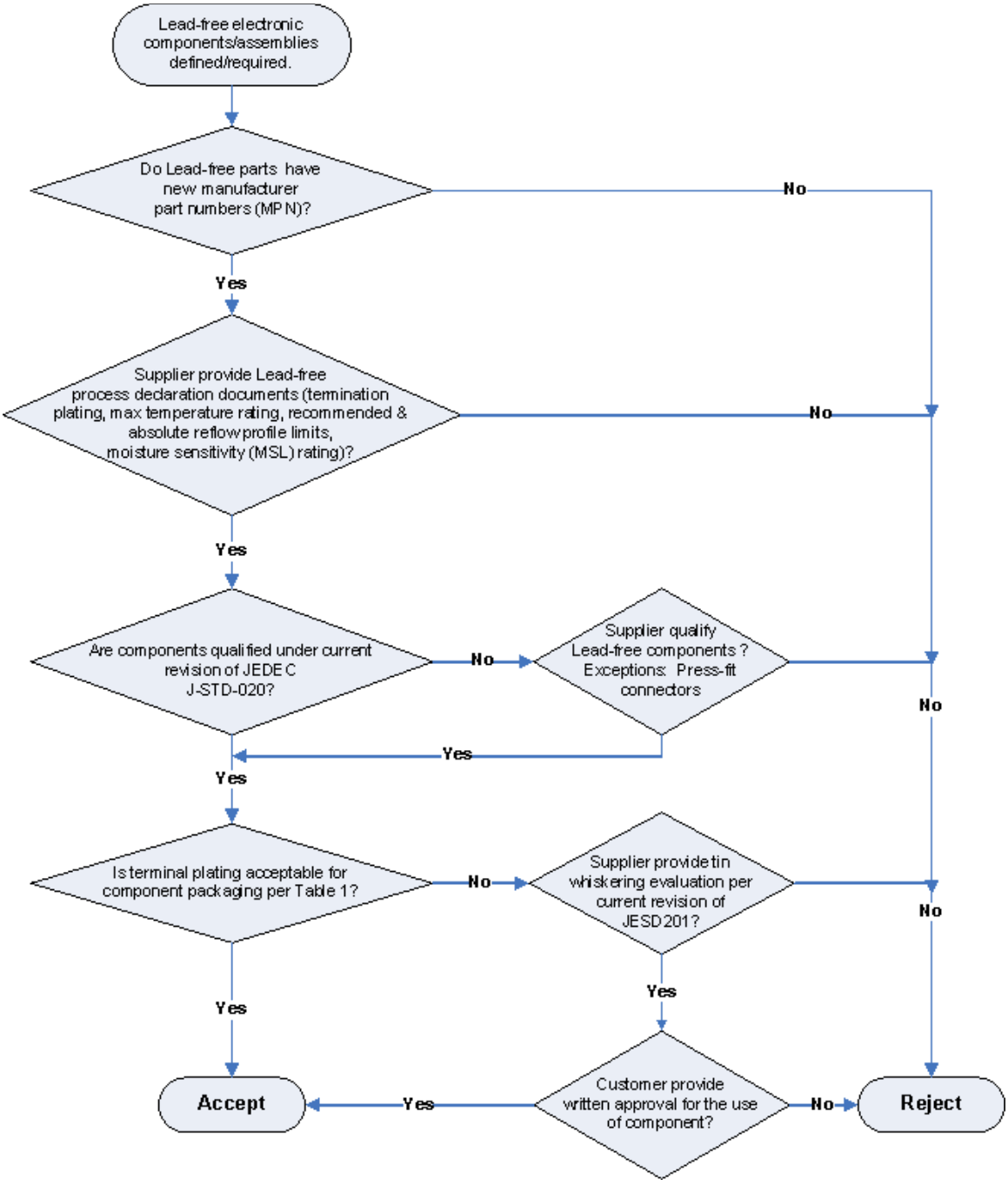

Figure.1: Flex' procurement flow diagram for Lead-free electronic component

8.0 PROCEDURE

8.1. Qualification Documentation

Suppliers must provide, or have available on demand, qualification documents or test information based on the list below. All the required tests should follow applicable industry standards, which include sample sizes, test procedures, acceptance criteria, reporting, etc. If an equivalent specification is used, details of testing procedures and conditions shall be provided to Flex.

a) Handling, Packing, Shipping and Use (per IPC/JEDEC J-STD-033)

b) Solderability testing (per IPC/ECA J-STD-002)
- Both no-clean and aqueous clean solder paste and wave solder flux should be included.

c) Solder joint reliability testing (per IPC-A-9701)

d) Mechanical shock and vibration (per AEC-Q100)

e) High temperature storage (per AEC-Q100/JESD22-A103)

f) Tin whisker growth testing (per JEDEC standard "JESD22A121 Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes" and "JESD201 Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes")

g) Moisture sensitivity level testing

i) For components which go through the reflow process
- In general, 260ºC reflow peak temperature is an overall requirement.
- Component moisture sensitivity levels should not exceed the levels for components currently being provided to Flex. It is recommended that both testing and the associated documentation include old vs. new part comparisons. MSL testing should follow IPC/JEDEC J-STD-020, with the exception that 6 heat cycles for area array packages and 4 heat cycles for other components should be included in pre-conditioning. *(The 6 heat cycle requirement reflects the maximum heat cycle an area array package can be expected to be exposed to, including: 2 reflows, wave soldering, component removal, reballing, and re-attachment).*
- Pre-conditioning for connectors should include 1 reflow at 260ºC peak temperature.

ii) For components (SMD and/or through-hole) which go through the wave soldering process
- Preheat - Ramp rate: 4ºC / s
- Solder pot temperature: 270ºC
- Contact time: 10s
- Thermal shock: 150ºC

iii) For components (SMD and/or through-hole) which go through the repair/rework process
- Preheat - Ramp rate: 4ºC / s
- Solder pot temperature: 275ºC
- Contact time: up to 40s (20s for removal, 20s for install)
- Thermal shock: 170ºC

iiii) Components, which may go through either reflow or wave soldering or both, should be qualified through both process conditions.

h) Lead-free component qualification data should include the following:
- Solder alloy used
- Termination metallurgy and thickness
- Preconditioning parameters used (including the reflow profile)
- Demonstration of both forward and backward compatibility, with the exception of area array packages with Lead-free balls that may not be backward compatible.
  - ❖ *Incompatibilities of Bi-containing termination with Sn-Pb solder, and Bi or Pb containing termination with Lead-free solder for through-hole waved soldered components, are of particular concern.*

i) For components which go through reflow process: Resistance to soldering heat (per MIL-STD-202 , Method 210F –method K, with 90-150 sec above the Sn-Ag-Cu Lead-free melting temperature 217ºC and 15 seconds above the peak temperature 260ºC.)

8.2. Lead Frame and Terminal Plating Requirement

8.2.1. Acceptable Platings

A potential reliability problem exists with Lead-free tin-plated components due to the phenomenon of "tin-whiskering" which may cause electrical shorting between leads of the same component or adjacent components, especially for fine-pitch components or closely spaced parts. The acceptable plating(s) for Flex Lead-free components are listed in Table 1 below.

Component Type	Acceptable Platings	Remarks
Lead-frame component (e.g. TSOP, QFP)	* Ni/Pd/Au * Matte Sn (>2nm) on top of Ni (>1.27nm) over Cu substrate * Matte Sn (1-4%)Bi (>2nm) over Alloy42 substrate	Solder Dip is allowed for >1.27mm pitch
Lead-less component (QFN, SOT, etc.)	* Ni/Au * Matte Sn (>2nm) on top of Ni (>1.27nm)	
Through-hole component	* Matte Sn (0-4%)Bi (>2nm) on top of Ni (>1.27nm) * Solder Dip	Through-hole components normally have the pitch greater than 1.27mm. Hence, solder dip is allowed.
Surface mount connector (solderable connection)	* Matte Sn (>2nm) on top of Ni (>1.27nm) * Ni/Au * Ni/Pd/Au	Solder Dip is allowed for >1.27mm pitch
Passive components (e.g. Capacitors or Resistors)	* Matte Sn (>2nm) on top of Ni (>1.27nm) * Ni/Au	Chip components without Ni-barrier may result in solder wicking and leaching
Through-hole connector (solderable connection)	* Matte Sn (0-4%)Bi (>2nm) on top of Ni(>1.27nm) * Ni/Au * Ni/Pd/Au * Solder Dip	Through-hole components normally have the pitch greater than 1.27mm. Hence, solder dip is allowed.
Press fit connector (solderless connection)	* Ni/Au * Matte Sn (>2nm) on top of Ni (>1.27nm)	
Mating side of all kinds of connector (solderless connection)	* Ni/Au * Ni/Pd-20%Ni/Au	
Plastic Ball Grid Array Packages (e.g. PBGAs, CSPs)	* Sn (3.0-4.0%) Ag (0.5-0.7%) Cu * Sn-Ag * Sn-Cu	
Ceramic Ball Grid Array Packages (e.g. CBGAs, CCGAs)	* Sn (3.0-4.0%) Ag (0.5-0.7%) Cu * Sn-Ag	Need more information and test for reliability proof
Other plated components (e.g. heat sinks, buss bars)	* Solder Dip * Matte Sn on top of >1.27nm Ni	Solder Dip is allowed only if the distance between the plated area and any current conducting paths is greater than 1.27mm

Table 1. Acceptable Platings of Different Electronic Components

Table Notes:

1) Suppliers need to provide adequate information and test results to prove the reliability of their products. (e.g. Tin whiskering acceleration test)
2) Lead-free solder dipping uses the family of Sn-Ag-Cu alloys which are also used as soldering alloys in surface mount, wave and rework assemblies of Lead-free process. The acceptable composition of Sn-Ag-Cu ranges from Sn-(3.0-4.0%) Ag-(0-1.0%)Cu
3) For ceramic packages, there is still no obvious data to prove which solder ball alloy is the best solution without potential reliability problem. Suppliers need to provide adequate information and test results to prove the reliability of their products.
4) Lead-free area array packages (CSP/BGA) and components with Bi-containing termination should not be used with Sn/Pb process due to reliability concerns.

Different Lead-free platings (other than Table 1) may be acceptable if suppliers provide reliability test documentation, in addition to any industry standard whisker acceleration tests, guaranteeing that their products do not pose potential reliability risks.

A waiver may be provided for components with thickness under the specified values in Table 1. if suppliers can provide adequate information to guarantee no potential reliability risks due to tin whiskering.

Some applications or customer requirements may prefer platings other than those listed in Table 1. These alternate platings will be acceptable **only** with written approval from Flex customers.

8.2.2. Unacceptable Platings

Platings identified below are either not acceptable under any circumstances or are not acceptable without specific approvals:

a) Bright Lead-free tin plating is NOT ACCEPTED at all.
b) Matte Lead-free tin-copper alloy plating is NOT ACCEPTED for most applications unless a WRITTEN APPROVAL is obtained from Flex customers.
c) Lead-free area array packages (CSP/BGA), and other components with Bi (>4%)-containing termination, are NOT ACCEPTABLE for use with Sn/Pb processes, due to reliability concerns.

8.3. PCB Requirements

8.3.1.PCB Performance Requirements

PCBs should adhere to the requirements of the European Union RoHS legislation and to meet the following performance requirements, using the solder materials and soldering processes as per Standards listed in Section 5.0.

a) PCB performance for board assembly (per PWB documentation)
- Solderability
- Warpage
- ICT probe-ability (as appropriate)
- Contact / key pad performance (as appropriate)
- Press-fit connector performance (as appropriate)

b) Reliability (per PWB documentation)
- Via and barrel integrity
- Solder mask integrity
- Lamination integrity
- IST testing incorporating microvias / vias / PTHs technology
  - Use the materials and processes, as defined in Section 8.3.2 for test vehicle preparation

c) Electrical performance (per PWB documentation)
- Conductive / cathodic anodic filament (CAF) resistance
- Cleanliness and surface insulation resistance (SIR)
- Tin whiskering

8.3.2. Lead-Free Solder Materials and Processes

a) Solder alloys: Sn-Ag-Cu for reflow; Sn-Ag-Cu or Sn-Cu for wave soldering
b) Soldering processes:
- SMT reflow: refer to Section 8.1(g)(i)
- Wave soldering: refer to Section 8.1(g)(ii)

c) Fluxes: no clean, water soluble

8.4. Application Compatibility

Fit, form, function or reliability (FFFR) of all the Lead-free version of parts, components or assemblies must be the same or better than those of the Tin-Lead parts. Latent damage to components due to the higher temperature of Lead-free process is of concern. Suppliers should be able to provide adequate information or

test results per applicable industry standards (e.g. Telcordia GR-468, if applicable) to prove that FFFR should not be altered after soldering processes as defined in 8,3,2.

8.5. Logistic Requirements

8.5.1. All Lead-free versions of parts, components or assemblies shall have new supplier P/N's assigned in order to distinguish from the Tin-Lead version P/N's. Suppliers may use existing part numbering with a change or addition in either prefix or suffix of the part number as long as the total part numbering schema is unique for Lead-free parts. If Lead-free parts are currently supplied to Flex, it is not necessary to have new part number provided the supplier can account for all components in the market ensuring **that Flex will not receive like numbered Tin-Lead components.**

8.5.2. Suppliers shall use industry standard Pb-free component marking per IPC/JEDEC J-STD-609.

8.5.3. All Lead-free components shall have traceable information marked on the outer packaging boxes and inner package material (e.g. tray, tube, reel) per the above industry standard marking schema. The component itself shall also contain this traceable information marking if there is sufficient room for such markings on the component.

8.5.4. Suppliers shall provide, or have available on demand, component datasheets for all Lead-free components. Datasheets must contain information on termination plating composition, maximum component temperature rating, recommended & absolute reflow profile limits, and the moisture sensitivity rating. If this information is not present on the datasheet, there should be a clear reference on the datasheet where the information can be located.

8.5.5. Suppliers shall provide to Flex a roadmap to show the planned changes, capacity and the timeframe for the availability of Lead-free products.

8.5.6. As per JESD46 , all changes from existing parts to Lead-free must be documented by a PCN issued by the manufacturer. Any changes related to Lead-free components should be considered major changes.

8.5.7. Sample devices and qualification data must be available to Flex prior to the release of the PCN or introduction of the new product.

8.5.8. Component suppliers must submit all product change notices (PCN) for approval to Flex 90 days prior to the effective dates. In the case of End of Life (EOL) notices, the supplier should provide written notice of planned Product Discontinuation per JEDEC Standard 48 (JESD48) to Flex as follows:

i) 6 months minimum from the notice for last order dates

ii) 12 months minimum from the notice for final shipment release dates.

All PCNs must be submitted in writing to pcn@flex.com.

Suppliers are expected to attend Flex PCN training for manufacturers available at:

http://www.flex.com/supplier/supplierquality/default.aspx

to understand and comply with Flex PCN Process.

8.6. RoHS Exemptions

8.6.1. The list of the exemptions is subject to change with respect to the RoHS legislation and should always be validated with the current consolidated version of the EU Directive 2011/65/EU.

8.6.2. If more than one exemption is taken, supplier must contact flex for approval.

9.0 RESPONSIBILITY

9.1. Supplier: Responsible to understand and adhere to all Lead-free component requirements provided by Flex. Supplier must stay current to all industry standards related to the testing, record retention and provide validation documentation upon request by Flex for Lead-free components.

9.2. Process/Component/Product Engineer: Must ensure Lead-free component selection meets the requirements set forth in this document. Validate and monitor manufacturing Lead-free processes. Conduct line qualification with consideration to Lead-free criteria.

9.3. Purchaser/Buyer: Must always ensure that the supplier is aware of all Flex requirements for Lead-free components and that the supporting document is sufficient and valid before material purchase.

10.0 RECORD RETENTION REQUIREMENT

10.1. Supplier must maintain all Flex required documents for a minimum of 10 years after end of life (EOL) of part/s supplied.