
National Semiconductor
The Sight & Sound of Information
Lead-Free
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Lead-Free
LEAD
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Lead-Free


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Lead-Free
Packaging

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Legislation

- The European Union's Directives are the most recent in a number of regulations aimed at eliminating hazardous substances from consumer products and the environment:
  - The restriction of Hazardous Substances (RoHS) Directive (2002/95/EC) will be effective starting July 2006. It aims at removing six substances from electrical equipment.
  - The Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) came effective in February 2003 and sets collection, recycling and recovery requirements for various categories of electrical products.

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RoHS concentration values

- **Maximum concentration values were approved by EU council on December 2004**
- **Maximum concentration values in homogenous materials of the RoHS restricted substances are:**

– Mercury	0.1% per weight	1000 ppm
– Cadmium	0.01% per weight	100 ppm
– Lead	0.1% per weight	1000 ppm
– Chromium (VI)	0.1% per weight	1000 ppm
– PBB	0.1% per weight	1000 ppm
– PBDE	0.1% per weight	1000 ppm

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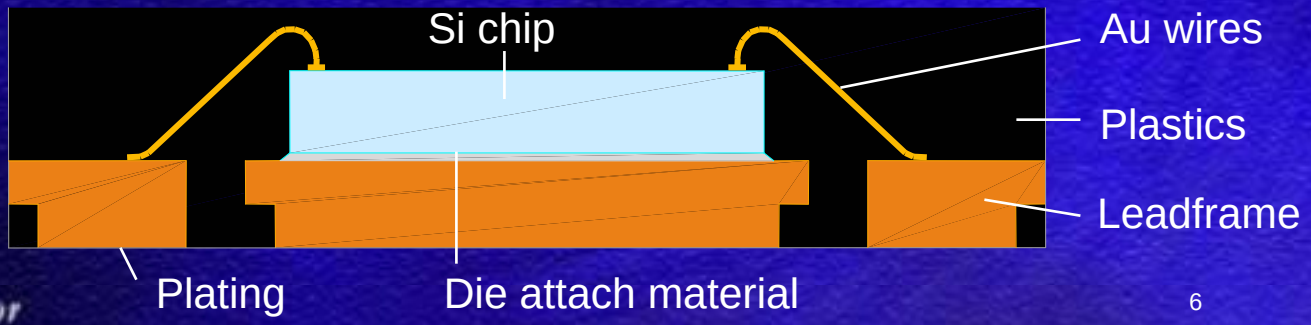
Homogenous material

- **Homogenous material means a material that can not be mechanically disjointed into different materials. (Separation by e.g. mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes)**
- **Homogenous material is any material which has a uniform composition throughout.**
  Examples in LLP Package:



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Green Team Charter:

Implement Regulatory & Customer Green Requirement through various functional organizations at NSC to address the concern of chemical content in National Semiconductor products and packing materials to ensure absence of banned substances.

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NSC EH&S Specifications

- **CSP-9-111C1 Supplier Product Specification**
  - Defines supplier & subcontractor responsibilities concerning product content, banned substances and material of interest of all assembly direct material and packing material.
- **CSP-9-111C2 Customer Product Stewardship Specification**
  - Describes the aspects of NSC EHSMS of interest to customers, especially mgmt of product stewardship & product content issues on all NSC products + its packaging materials
- **CSP-9-111S2 Banned Substances and Materials of Interest**
  - Contains list of banned substances & material of interest.

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NSC Product Compliancy

1. **Mercury (Hg), Cadmium (CD), Hexavalent Chromium (Cr VI), Polybrominated Biphenyls (PBB) and Polybrominated Diphenyl Ethers (PBDE) are already banned by NSC and are not contained in NSC products or used in production processes.**

2. **Lead-free**

Definition	Substance	Upper Limit	Materials
Lead-free	Pb	< 1000 ppm	Lead finish

National Semiconductor's Pb-free products are RoHS compliant

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NSC Product Compliancy

3. NSC's RoHS compliant products do not contain Pb, Hg, Cd, Cr VI, PBB and PBDE as either intentionally added ingredients or as unintended impurities.
4. Lead used in High Pb-content alloys (> 85% Pb) is exempted by the RoHS directive. Example: Die Attach material in power package types like e.g. TO-263

In case packages contain High Pb-content alloys, the product is still considered RoHS compliant.

5. For banned and reportable substances please refer to NSC document:
   http://www.national.com/quality/green/files/(SC)CSP-9-111S2.pdf

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NSC Product Compliancy

- **The composition of National's product is the sum of the constituent materials. Consequently:**
  - 100% of direct raw materials and packing materials are certified annually by suppliers. Analytical data required as evidence.
  - All current and prospective suppliers must complete National's certification and submit ICP test data for 4 banned metals.
  - All packing materials, which are destined for customers have the same certification and data submission.

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NSC Product Compliancy

- **Chemical composition information**
  - Listing of all materials plus weight and CAS# in each device for SnPb and Pb-free lead finish.
  - Device content is approximate and based on engineering estimates only. Indicates intentionally added substances.

Chemical Composition for LM2901M (Pb-Free)

Item	Component	CAS#	% of Component in item	Weight of Item (mg)	Weight of Component (mg)	ppm of component in package
Leadframe	Cu	7440-50-8	97.45	42.69	41.601	321122
	Fe	7439-89-6	2.4		1.025	7908
	Zn	7440-66-6	0.12		0.051	395
	P	7723-14-0	0.03		0.013	98
Plastic	SiO2	60676-86-0	69.26	79.56	55.103	425343
	Epoxy Resin	25928-94-3	28		22.277	171955
	Sb2O3	1309-64-4	2		1.591	12282
	Br	7726-95-6	0.74		0.589	4544
Chip	Si	7440-21-3	99.4	3.25	3.231	24936
	Al	7429-90-5	0.6		0.019	150
	As (dopant)	7440-38-2	1.00e-10		3.25e-12	2.51e-08
	Sb (dopant)	7440-36-0	1.00e-10		3.25e-12	2.51e-08
	B (dopant)	7440-42-8	1.00e-10		3.25e-12	2.51e-08
	P (dopant)	7723-14-0	1.00e-10		3.25e-12	2.51e-08
	Ge (dopant)	7440-56-4	1.00e-10		3.25e-12	2.51e-08
Die Attach	Ag	7440-22-4	75	0.36	0.27	2084
	Epoxy Resin	25928-94-3	25		0.09	694
Wires	Au	7440-57-5	100	0.35	0.35	2701
Ext. LeadFinish	Sn	7440-31-5	100	3.01	3.01	23234
Int. LeadFinish	Ag	7440-22-4	100	0.33	0.33	2547
Total:					129.55	1,000,000

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NSC Product Compliancy

- **Green Compliance Data**
  - Analytical test data of raw materials and packing materials.

Green Compliance

Banned Substances Report Generated 03/09/2005

Look Up Another Part Number

PART NUMBER: LM2901M			PACKAGE: SOIC NARROW, 14 Leads		
Material	**Cd**	**CrVI**	**Pb**	**Hg**	**Ref #**
Packing : cond bag	<0.5	<1	<1	<0.5	552
Packing : paperboard	N.D.	N.D.	N.D.	N.D.	40
Packing : green pin/natural pin/green plug/natural plug	N.D.	N.D.	N.D.	N.D.	533
Packing : green pin/natural pin/green plug/natural plug	N.D.	N.D.	N.D.	N.D.	532
Packing : rail	N.D.	N.D.	N.D.	N.D.	526
Lead Frame/Substrate	0.127	6.682	13.137	0.011	53
Mold Compound	<0.5	1.5	<10	<0.5	569
Die Attach	<5.0	<5.0	<5.0	<5.0	32
Wire Type	N.D.	N.D.	N.D.	N.D.	75

* **Cd**: Cadmium, **CrVI**: Hexavalent Chromium, **Pb**: Lead, **Hg**: Mercury, **ND**: Not Detected
* Unless otherwise noted, units are in PPM (parts-per-million)

- Ref #552: Analysis by CHEM VI SDN. BHD per Report #LS/0404/7314 on 10/5/2004
- Ref #40: Analysis by PSB-SINGAPORE per Report #57S042143EO on 5/20/2004
- Ref #533: Analysis by CHEM LAB MALAYSIA per Report #PG/MS/0581-0583/2004 on 5/26/2004
- Ref #532: Analysis by CHEM LAB MALAYSIA per Report #PG/MS/0581-0583/2004 on 5/26/2004
- Ref #526: Analysis by CHEM LAB MALAYSIA per Report #PG/MS/0697/2004 on 6/17/2004
- Ref #53: Analysis by NABBIR LABS SDN.BHD. per Report #4UO4026 on 4/17/2004
- Ref #569: Analysis by ALS-TECHNICHEM SDN. BHD. per Report #ATHQ/18784BS/2004 on 7/23/2004
- Ref #32: Analysis by SGS-TAIWAN per Report #CE/2004/30804 on 3/12/2004
- Ref #75: Analysis by SGS-TAIWAN per Report #CE/2004/31387 on 3/16/2004

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Certification of Compliance

CERTIFICATION
OF
COMPLIANCE AND CHEMICAL CONTENT

The undersigned, an employee and authorized representative of National Semiconductor certifies that to the knowledge of National Semiconductor as of the date below:

- **Substances listed in *Table of Banned Substances* are not intentionally added to National Semiconductor products and packing materials, except lead in solder and ceramics.**
- **Lead-free products, which are designated 'NOPB', are compliant with European Union Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS). Performance requirements of certain specialized products necessitate the use of RoHS exempt high melting temperature tin/lead solder alloy or ceramics containing lead. If designated 'NOPB', these products are also RoHS compliant.**
- **Trace impurity concentrations of banned substances are < RoHS or other regulatory limits.**
- **Trace impurity concentration of cadmium in plastic materials is <5ppm.**
- **National Semiconductor products do not contain and are not manufactured with substances subject to The Montreal Protocol on Substances that Deplete the Ozone Layer and U.S. Clean Air Act. Title VI. i.e. ozone depleting substances.**

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MSL & Pb-Free Availability

- **Lead-Free availability and Moisture Sensitivity Information of all packages/devices can be found within the Product Folder:**

LM2901 Product Folder

General Description | Features | Datasheet | Package & Models | Samples & Pricing | Reliability Metrics | Design Tools | Application Notes

Package Availability, Models, Samples & Pricing

Part Number	Package			Status		Models		Samples & Electronic Orders	Budgetary Pricing		Std Pack Size	Package Marking Format
	Type	Pins	MSL Pb-Free Availability	Lead Time	Qty	SPICE	IBIS		Qty	$US each		
LM2901M	SOIC NARROW	14	Status	Full production / 4-5 weeks	250000	N/A	N/A	24hr Samples / Buy Now	1K+	$0.19	rail of 55	NSUZXYTT LM2901M
LM2901MX	SOIC NARROW	14	Status	Full production / 4-5 weeks	250000	N/A	N/A	Buy Now	1K+	$0.19	reel of 2500	NSUZXYTT LM2901M

MSL & Pb-Free Availability

Packaging

Moisture Sensitivity Level Data and Lead-Free Status for LM2901M

NSID	MSL @ Peak Reflow Temperature Degrees C		Lead-Free Status
	Std 235	260	
LM2901M	1	1	Available as Pb-free

- If parts are '**Available as Pb-Free** ' they can be ordered with suffix NOPB, e.g. LM2901M NOPB, or with suffix 260C
- Availability by NSID, Package type or Package Pin Count
  - http://www.national.com/packaging/parts/
  - http://www.national.com/cgi-bin/msl.cgi

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MSL rating Definition

- **Definitions of MSL Levels (as per J-STD-033)**

  Floor Life (out of bag) at factory ambient < 30degC/60%RH

  - MSL 1 (no dry pack): Unlimited at < 30degC/85%RH
  - MSL 2: 1 year - after opening dry-pack
  - MSL 2A: 4 weeks - after opening dry-pack
  - MSL 3: 7 days - after opening dry-pack
  - MSL 4: 72 hours - after opening dry-pack

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Order Suffix (Examples)

- **LM2750LDX-5.0 (standard device)**
  - **Lead Finish: SnPb; MSL1; max peak body temperature 235ºC; no dry pack bag necessary**
- **LM2750LDX-5.0 NOPB**
  - **Lead finish: Sn; MSL3; max peak body temperature 260ºC; dry pack bag necessary**
- **LM2750LDX-5.0 260C**
  - **Lead finish: SnPb; MSL3; max peak body temperature 260ºC; dry pack bag necessary**

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Lead-Free Packages

- **Overview of available Pb-free package families:**

SOIC	TSSOP	PQFP	LQFP
TQFP	PLCC	TO-220	TO-263
TO-92	SOT23	SOT223	TO-252
Micro SMD	LLP	Lam CSP	FBGA
SC70	Mini SOIC	SSOP	MDIP

- **Note: MSL level can drop for some package types in Pb-free version**
  Some pin counts are not yet qualified.
  For micro SMD packages, only thin micro SMDs are available in Pb-free version.

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Lead-Free Solutions

- **NSC qualified following Pb-free platings / bump alloys:**

Package Type	Standard Composition	Pb-free Composition	Pb-free Plating Thickness
Leaded Packages and LLP	85Sn / 15Pb	Matte Sn	min 8 microns, nom 12 microns
TO-92	85Sn / 15Pb	99.3Sn / 0.7Cu	min 8 microns, nom 12 microns
Micro SMD	63Sn / 37Pb	95.5Sn / 4.0Ag / 0.5Cu	N/A
Ball Grid Array	63Sn / 37Pb	96.5Sn / 3.5Ag	N/A

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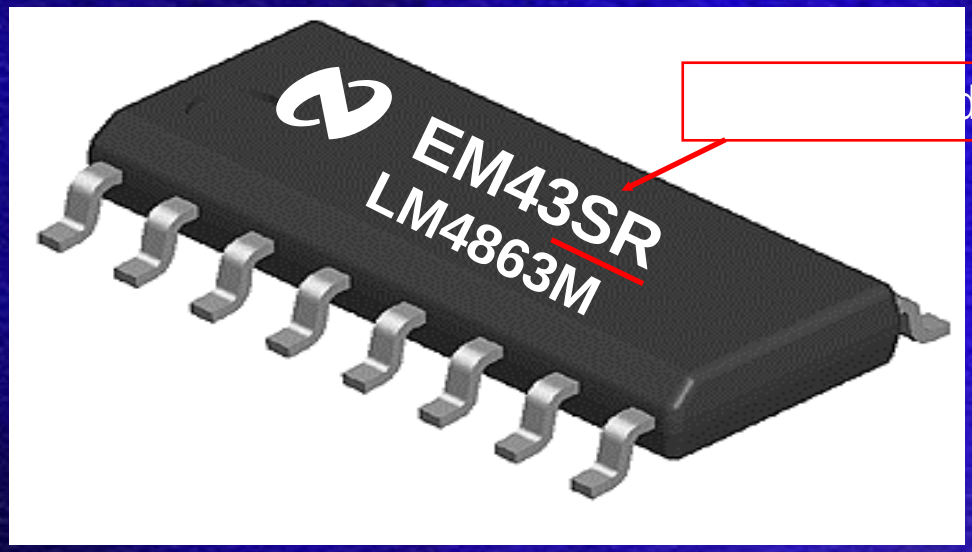
Supply Chain Identification

- **Marking of lead-free components**

  Parts have dedicated Die Run Code (part of Date Code) from RA, RB, … , ZZ except XX



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Supply Chain Identification

- IC Top surface body marking
  - Pb-free: Die Run Code from **RA** to **ZZ**
  - Standard SnPb: Die Run Code beginning with **AB** to **QZ**.

UZYWTT with U - fab code; Z - assembly site code; YW - 2 digit Date Code; TT - Die Run code.

XS34**TB** This is a lead-free part as the dierun code, **TB,** is beyond RA.

JM330**BA** This is a part with standard lead finish (non lead-free).

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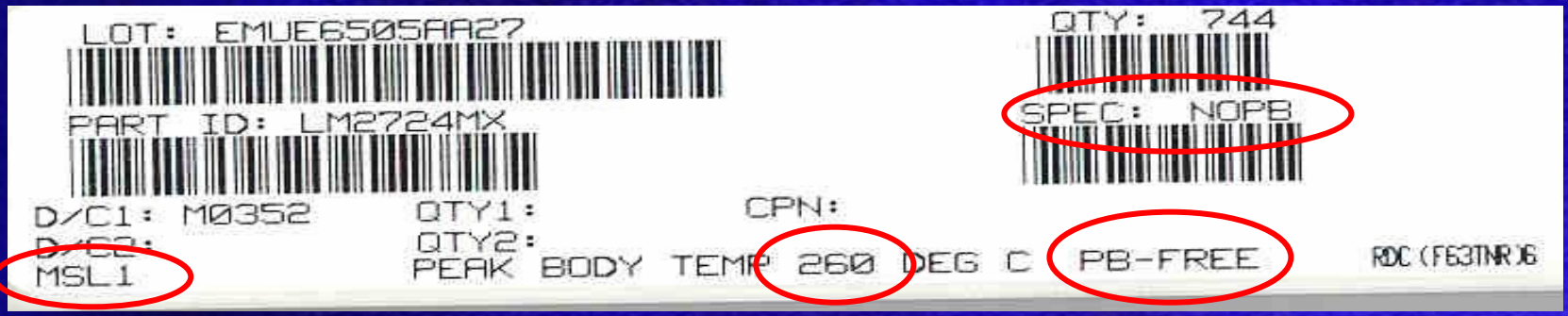
Supply Chain Identification

- Bar-code Label
  - Tape and Reel label, Dry pack bag will show MSL level and state PB-FREE if applicable.
  - The SPEC field will show NOPB

Example: Tape & Reel Label



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Supply Chain Identification

- Bar-code Label

  Example: Box Label

  – NSC will implement marking scheme as recommended by *JESD97*.
    - PB-FREE on all labels
    - e1-e7 on all labels and on device marking if no space constraints

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Forward / backward compatibility

- **Forward compatibility**
  - **Can standard component with SnPb lead finish be used in Lead-Free soldering process and Lead-Free solder paste (240ºC - 260ºC)?**
  - **MSL degration due to higher temperatures?**
  - **Dry Pack vs No- Dry Pack?**
  - **Boxstock inventory?**
- **Backward compatibility**
  - **Can Pb-Free component be used in Lead containing soldering process and Lead containing solder paste (220ºC - 235ºC)?**

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Forward / backward compatibility

- **For leadframe based packages (LLP still under evaluation)**

Lead finish	SnPb Process (220ºC – 235ºC)	Pb-free Process (240ºC -260ºC)
SnPb	OK	OK if ordered with suffix 260C (forward compatible)
Pb-free	OK (backward compatible)	OK

- **For micro SMDs and Area Array Packages (BGAs)**

Lead finish	SnPb Process (220ºC – 235ºC)	Pb-free Process (240ºC -260ºC)
SnPb	OK	Not recommended (not forward compatible)
Pb-free	Not recommended (not backward compatible)	OK

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Forward compatibility

MSL @ Peak Reflow Temperature Degrees C	
Std 260	260
1	1

→ Forward Compatible

MSL @ Peak Reflow Temperature Degrees C	
Std 235	260
3	4

→ Not Forward Compatible

MSL degration

MSL @ Peak Reflow Temperature Degrees C	
Std 235	260
1	1

→ Not Forward Compatible

Different mold compounds

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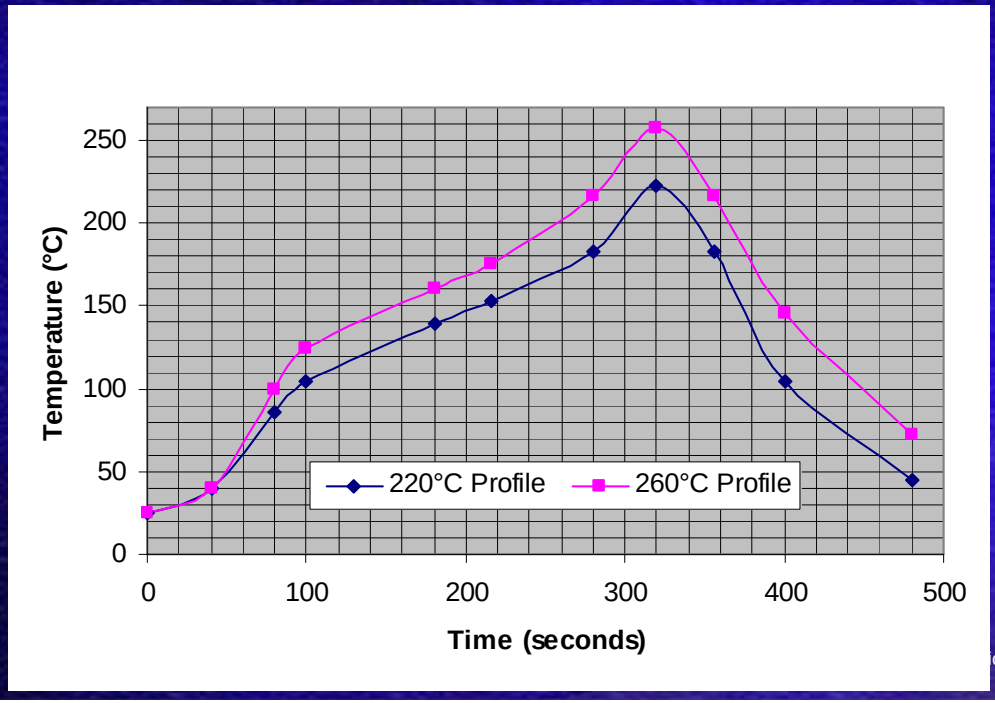
Lead-free qualification

- **Moisture Sensitivity Level (MSL) Reclassification:**
  - **Preconditioning: All selected package types are subjected to 3x 260°C reflow regardless of package thickness and volume.**
  - **In compliance with Jedec Standard J-STD-020C**



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Lead-free qualification

- **Jedec Standard J-STD-020C**
  - **Requirements:**
    - **Maximum peak body temperature: 260 ºC +0/-5 ºC**
    - **Dwell time at peak for small Pb-free devices: 20 – 40 sec**
  - **J-STD-020 is *specification for classification of moisture sensitive device.***
  - **J-STD-020 is *not a process recommendation for reflow soldering*.**
  - **Mis-interpretation possible for min / max values**

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Lead-free qualification

- **Package Level Qualification**
  - TMCL (-65°C /+150°C), 1000 cycles
  - THBT, 1000 hours
  - HTSL, 1000 hours
  - ACLV, 96 hours
  - Solderability (Wetting Balance)
  - Whisker Test (THBT, 1000 hours, 300x SEM inspection)
  - Terminal robustness
- **Board level Qualification**
  - TMCL (-40°C/+125°C), 1050 cycles
  - Drop Test (IEC 68-2-32), for LLP package only
  - Vibration Test, for LLP package only

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Tin Whisker Mitigation

- Thick Sn layer > 8 microns
- Annealing process (as per NEMI recommendation):
  1hr post bake at 150°C within 24hrs of plating process
- NSC follows NEMI recommendations on whisker testing:
  (tests are still ongoing)

Test	Conditions	Time Points	Final Time Point	Inspection
1	Ambient	1st checkpoint at 1,000 hr, 2,000 hr, and every 2,000 hr thereafter	17,000 hr (24 months)	SEM at 300X
2	T/H 60ºC / 93% RH	Every 1,000 hr	9,000 hr (13 months)	
3	TMCL–55/85ºC	Every 1,000 cycles	3,000 cycles (6 weeks)	

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Tin Whisker Mitigation

- **Latest update on NEMI recommended stress tests:**

	Leadframe Material after 2 x reflow @ 250°C			
Stress Test	Cu7025	Tamac2	Olin151	Cu194
2000hr ambient	no whiskers	no whiskers	no whiskers	no whiskers
2000hr 60°C / 93% RH	28 µm	34 µm	9 µm	10 µm
3000 cycles TMCL (-55/85°C)	29 µm	36 µm	21 µm	21 µm

- **The current NEMI recommendation for maximum allowable whisker length is 50 microns.**
- **JEDEC has not published a value for maximum allowable whisker length.**

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Transition to Lead-free

- **Dual availability of SnPb and Pb-free parts**
  - So far >90% of NSC's products are available in Pb-free version
  - Availability of SnPb parts after July 2006 depending on volumes, subcontractors, etc.. So far no plans yet to discontinue SnPb parts.
  - > It is customer' responsibility to order Pb-free parts
- **Part number change**
  - Pb-free parts need to be ordered with suffix NOPB or with special part number
- **Forward / Backward compatibility given with suffixes '260C' and 'NOPB'**

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Lead-free Samples

- **Pb-free samples on the web**
  - Standard and NOPB parts can be ordered on external NSC web site and will be shipped within approximately 5 working days

Country or Region	Estimated Delivery
United States	24 hours
Europe	4-15 days
Taiwan	3-15 days
South Korea	3-15 days
Japan	3-15 days
All Others	3-15 days

Please note:
The 24 hour sample delivery is subject to availability in your region. The delivery times shown to the left are typical estimates and are not guaranteed.

Check here ☐ for "Pb Free" package.
(not available in 24 hour delivery)

  - Sample units will be dry packed (if necessary) and labeled as PB-FREE

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Green Package

- **Green Package**
  - NSC's plastic encapsulated ICs typically contain antimony-trioxide (Sb_2O_3) and bromine based (no PBB and PBDE) flame retardants
  - Evaluation of halogen- (usually bromine) and antimony-free mold compounds and substrates is ongoing
  - Target date for qualification completion of green packages is May 2006.

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Green Package

- In the context of this project, ***halogen-free*** refers to Pb-free packages, which meet the following requirements:

Pb	< 1000ppm (lead finish, solder ball)
Σ (Br + Cl)	< 1000ppm (mold compound, laminate, and solder resist)
Antimony	< 1000ppm (mold compound, laminate, and solder resist)

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NSC Website: FAQ

- **http://www.national.com/packaging/leadfree/**

Useful NSC website

- http://www.national.com/quality/green/
- http://www.national.com/packaging/leadfree/
- http://www.national.com/packaging/leadfree/faqs.html
- **For banned and reportable substances**
  http://www.national.com/quality/green/files/(SC)CSP-9-111S2.pdf
- **Lead-Free availability and Moisture Sensitivity Info**
  - http://www.national.com/packaging/parts/
  - http://www.national.com/cgi-bin/msl.cgi
- **Material content information.** Listing of all materials plus weight and CAS# in each device on the web for SnPb and Pb-free lead finish
  http://www.national.com/packaging/parts/

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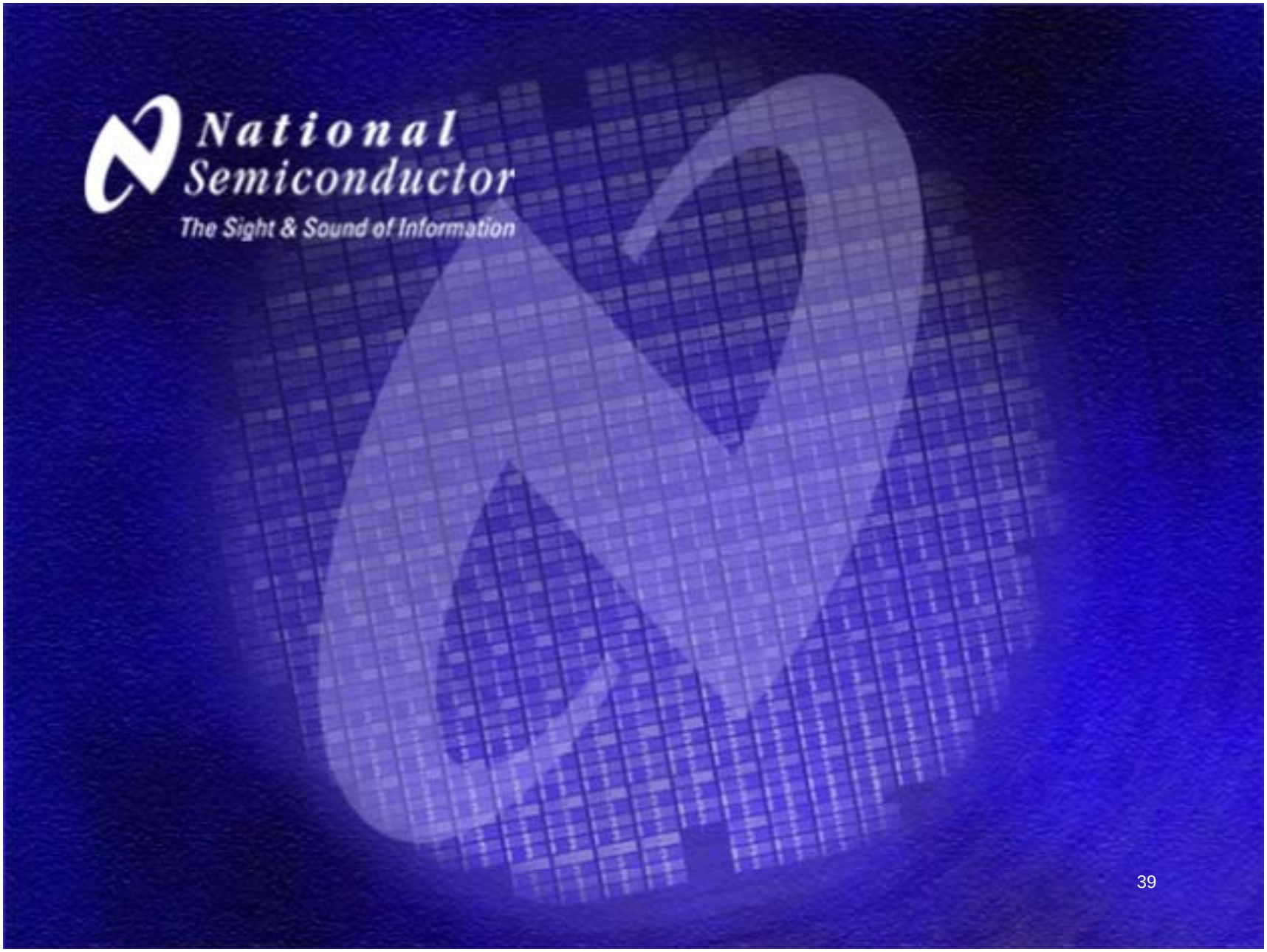
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