Impacts of RoHS on the Electronic Component Supply Chain

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Arrow Electronics
Worldwide Statistics for 2005

NYSE:	**ARW**
Sales:	**$11 billion**
Employees:	**11,500**
Inventory:	**$1.5 billion**
Locations:	**225 sales facilities In 53 countries**
Fortune 500 Ranking:	**#207**

Commitment to RoHS: Arrow is committed to providing efficient, responsible, global solutions that help our customers meet the challenges of environmental compliance.

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Impact on the Supply Chain

Regulations present tremendous complexity:

Variances in the timing of supply transition plans

Legislative "exemptions" cannot ensure stable supply

Evolving nature of environmental regulations

Differing manufacturing requirements make mixing of parts potentially unsafe

Variances in supplier policies

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Impact on the Supply Chain

- **Can any domestic manufacturer ignore the impact of these regulations?**
  - Probably not.
  - As component suppliers develop RoHS Compliant versions of their components many will discontinue the original part.

Consider the economic feasibility for suppliers to continue with two versions of each component

  - Supply disruptions, particularly on leaded parts, may begin to occur at any time.
  - Many industry leaders believe the entire market will go completely lead-free

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Sources of Complexity

- **Environmental regulations continue to evolve**
  - Most are following guidelines established in RoHS

- **Variances in Supplier Timing and Policy:**
  - **Suppliers developing their transition plans and migrating to lead-free versions at very different rates**
    - Most suppliers have completed their transition, but some will not be completed until Q1/Q2 of 2006, or later.
    - We have already seen an increase of EOL notices for leaded devices

  - **Some suppliers are planning to transition to lead-free without changing the base part number**
    - This makes the process of ordering, identifying and keep lead-free and leaded part inventories very difficult

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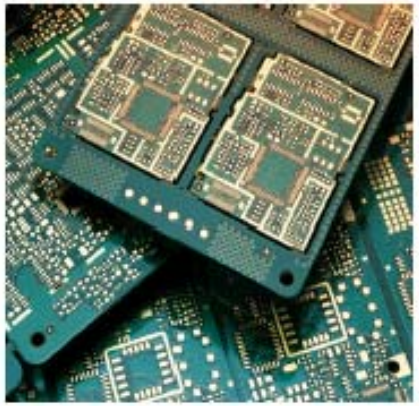
Analysis of SEMI & PEMCO Suppliers

Suppliers Changing Their Part Numbers



- 78% of NAC SEMI Suppliers <u>are</u> changing Part Numbers.
- 44% of NAC PEMCO Suppliers <u>are</u> changing Part Numbers.

RoHS Compliant Product Availability

	SEMI	PEMCO
• 90% of Suppliers fully converted:	Q1 ‘06	Q2 ‘06

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Impacts on Component Manufacturers

Must Dos

- Find lead-free alternative for traditional tin-lead plating
- Assure no other restricted substances are present in products
- Manage transition, internally and externally
- Meet the RoHS directive well in advance of the EU requirement deadline of July 1, 2006

Complexity

- Not all OEMs / EMSs are on the same time schedule
- Not all OEMs / EMSs have the same requirements
- Lack of clarity on how much compliance information must be provided

In the meantime…

- Keep supplying traditional versions to customers with exemptions or other needs for noncompliant product

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Sources of Complexity for the Supplier

Many different elements of component terminations must be re-qualified:

- Solderability
- Solder joint reliability
- Compliant pin process conditions
- Compliant pin reliability
- Mechanical shock and vibration
- High temperature storage
- Tin Whisker growth after termination
- Moisture Sensitivity Level
- Compatibility (forward / backward)

As suppliers find what works best, there can be minor and major shifts in their transition plans

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Sources of Manufacturing Complexity

Compliant parts don't always mix well with non-compliant components (continued)

Backward Compatibility - NOT always a guarantee!

- Issues w/ BGA's (SnAgCu solder balls)
- Solderability variations on component terminations can cause different results by component.
- Lead-Free termination coatings may not adhere due to lower process temperature (component / supplier dependent)

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Sources of Manufacturing Complexity

Compliant parts don't always mix well with non-compliant components

Forward Compatibility - Lead contamination on a lead-free solder joint could significantly reduce the reliability of the joint

- **Temperature**: Lead-free alloys melt at higher temperatures (217^{o} C+) than Tin-lead alloys (usually 183^{o} C)
  - Increased temperatures can damage components, plastics can melt, ICs may delaminate, PCBs may warp or crack, board "tourqing" can cause joint cracking, part popping, chip epoxying .
  - Both components and PCB will need to withstand higher temperatures
  - Be sure that your manufacturing process is designed to handle higher temperatures
- **Lead Contamination** significantly devalues solder reclaim

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Sources of Manufacturing Complexity

The Moisture Sensitivity Level (MSL) of a component may shift 1 to 2 levels with RoHS compliance.

IPC/JEDEC Standard J-STD-020 Moisture/Reflow Sensitivity Classifications

Of nonhermetic solid state surface mount devices sensitive to moisture induced stress

Once MSL is identified, the SMD can be properly packaged, stored and handled to avoid subsequent thermal and mechanical damage during the solder reflow attachment and/or repair operation

Level	Floor Life	
	Time	Conditions
1	Unlimited	≤ 30 C / 85% RH
2	1 year	≤ 30 C / 60% RH
2a	4 weeks	≤ 30 C / 60% RH
3	168 hours	≤ 30 C / 60% RH
4	72 hours	≤ 30 C / 60% RH
5	48 hours	≤ 30 C / 60% RH
5a	24 hours	≤ 30 C / 60% RH
6	Time on Label	≤ 30 C / 60% RH

Sources of Manufacturing Complexity

Reliability Risks associated with pure Tin

Tin Whiskering –

- **DEPARTMENT OF THE AIR FORCE 9 May 2005 AIRWORTHINESS ADVISORY** on Lead-Free Solder:
  - "To date, **no lead-free solders are known to have met the reliability requirements imposed upon military electronics**."

  - **The Department of Defense has therefore prohibited the use of pure tin (e3 per JEDEC JES D97 standard) for military applications** due to confirmed risks associated with tin whiskers.
    - If a lead has more than 3% of some other element, it may be sufficient to retard whisker growth.
    - DOD standard is that a lead must contain no more than 97% tin.

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Analysis of Component Terminal Finish trends

As of January 2006, of the Arrow franchised suppliers providing terminal finish information:

Terminal Finish*	% of Parts**
• Sn	42%
• SnPb	27%***
• Matte Sn	19%
• Sn/Cu	5%
• Ni/Sn	4%
• Cu/Ni/Pd/Au	1.6%

Notes:

(*) Manufacturers have reported use of 49 different terminal finish types to Arrow

(**) Data represents >2.7M total parts, the majority being PEMCO

(***) These are not RoHS compliant parts and may transition

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Sources of Manufacturing Complexity

Steps for Lead Free Production *

1. Obtain suitable components (Arrow can help)
2. Choose solder alloy types for surface mount technology (SMT), wave and hand soldering
3. Choose lead-free laminate
4. Choose printed circuit boards (PCB) and protective coating
5. Assess suitability of equipment and techniques
6. Run production trials
7. Optimize the profiles and process conditions
8. Train the staff
9. Inspect and test products

NOTE *: Refer to ERA Technology - Project No. 043121477
Report: Lead Free Soldering – approach to changing from tin.lead to lead free soldered products
Posted on www.Arrow.com/green

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Sources of Manufacturing Complexity

Component Issues – Maximum Reflow Temperatures *

Component	Max. temperature
Aluminium electrolytic capacitor – maximum temperature depends on size	240 - 250°C
Tantalum capacitor – various types	220 - 260°C
MLCC (ramp rate more important)	240 - 260°C
Film capacitor (depends on plastic film type)	230 - 300°C
SMT relay (plastic deformation)	226 - 245°C
Crystal oscillator (plastic deformation)	235 - 245°C
Connectors – depends on type of plastic used	220 - 245°C
LED – may function but light output affected	240 - 280°C
ICs	245 - 260°C

NOTE *: Excerpt from ERA Technology - Project No. 043121477
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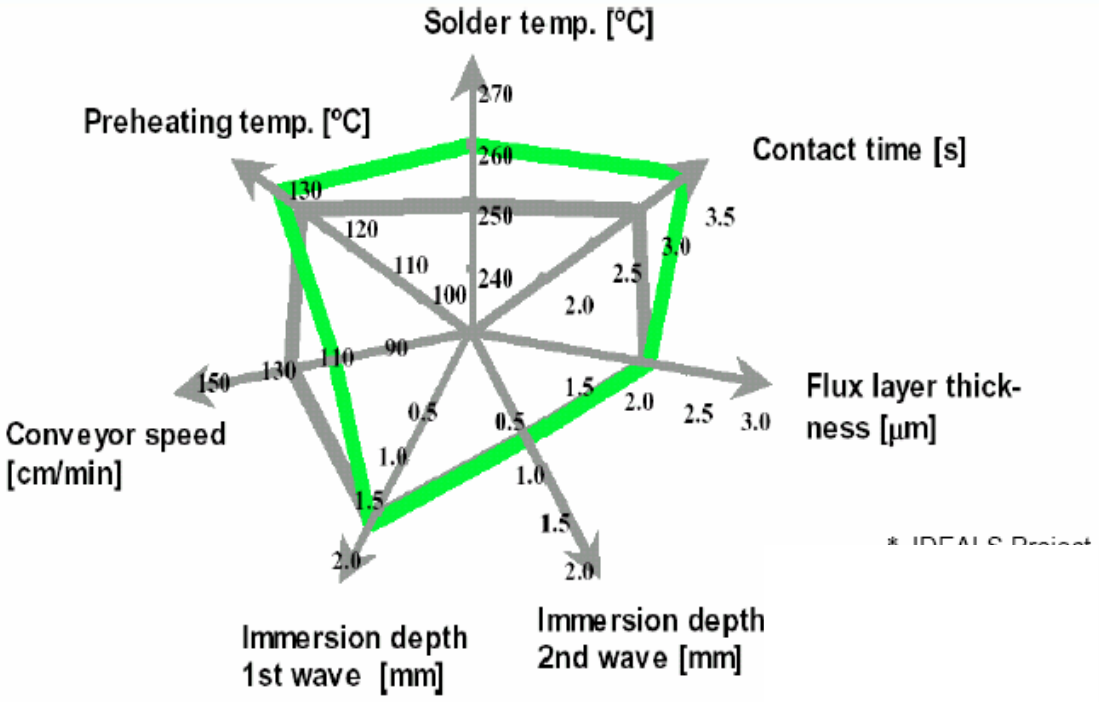
Sources of Manufacturing Complexity

Lead-Free Soldering

- **No "drop-in" lead-free replacement for tin-lead**
- **All of the alternatives are different**
- **Process window with LeadFree is much smaller than with tin/lead**
  - Better process control is essential
- **Production of a reliable product is possible if:**
  - Differences are understood
  - Appropriate lead-free process conditions are developed.

Process Window Change



Source: Fry's Metals Inc. Alpha Metals, LTD

Sources of Manufacturing Complexity

Choosing Lead Free Solders *

Alloy composition	Melting Pt °C	Comments
Sn0.7Cu	227	Recommended for wave soldering applications (known as 99C)
Sn3.5Ag	221	Wetting inferior to SnAgCu but used where higher melting point is required
Sn3.5Ag0.7Cu (and variations on this)	217	Most widely used lead-free alloy. Various percentages of silver and copper are used. Recommended by NEMI for surface mount
SnAgBi alloys (some with Cu)	~ 210 - 215	Better wetting properties than SnAgCu but must not be used with lead. Mainly used as solder paste but has been used for wave soldering, mainly in Japan. Wire not available so rework difficult
Sn9Zn	198	Zinc-containing alloys are difficult to use, need special fluxes and are susceptible to corrosion but new solder pastes with reasonable soldering performance have recently been developed.
Sn8Zn3Bi	~ 191	Used by several Japanese manufacturers where heat sensitive components are used. Includes NEC and Matsushita. Paste made by Senju. Difficult to use, needs nitrogen for SMT
58Bi42Sn	138	Low melting point, hard, brittle alloy but performed well in reliability trials

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Sources of Manufacturing Complexity

Choosing Printed Circuit Board coating *

PCB coating	Advantages	Disadvantages
Organic solderability preservatives (OSP)	Lowest cost lead-free option. Very thin and electrical contact can be made.	Fragile and easily damaged by handling. Protection during storage for shortest of all alternatives, at best 6 months but less if stored in hot humid conditions. Incompatible with some fluxes.
Immersion silver	Thin flat coating with good solder wetting. More robust that OSP and less than half cost of ENIG.	Solder wetting deteriorates if stored in atmosphere with sulphides. Protection during storage for ~ 6 months but can be less.
Immersion tin	Thin flat coating with good solder wetting. More robust that OSP and lower cost than ENIG.	Solder wetting deteriorates during storage, particularly at high humidity. Protection during storage for ~ 6 months but can be less.
Electroless nickel / immersion gold (ENIG)	Best protection of all immersion coatings, up to ~ 1 year in storage. Gold has very good solder wetting.	Most expensive option. Sometimes used to make electrical contacts but these can deteriorate.
Lead-free HASL (SnCu solder)	Good corrosion resistance, flat surface, good solder wetting.	Needs new equipment. High temperature can damage PCB, very good process control needed, boards usually need to be pre-baked.
SnPb HASL (for comparison)	Well understood, good protection, excellent solder wetting and corrosion resistance.	Thermal damage to PCB, surfaces tend to be uneven so not suitable for some large low profile components.

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Sources of Manufacturing Complexity

Running Lead Free Production Trials *

- Surface Mount Technology
  - Evaluate various solder pastes for suitability
  - Existing ovens may be suitable….forced air convection ovens, minimum of 7 zones are ideal
  - Solder paste suppliers will suggest reflow profiles
  - Different profiles may be needed for each PCB design.
- Wave Soldering
  - Possible to convert some existing machines to operate with lead-free solders
    - Consult your machine vendor
  - Lead-free flux required
  - Optimize temperature profile for each PCB design
  - Analyze solder regularly to ensure no significant changes or lead contamination from use of tin-lead terminated components.
- Hand Soldering
  - Longer wetting time and inferior flow vs. tin/lead solder – reduces throughput
  - Reduced tip life
  - New soldering irons have better temperature control to enable faster wetting, lower temps, longer tip life.

NOTE *: Refer to ERA Technology - Project No. 043121477
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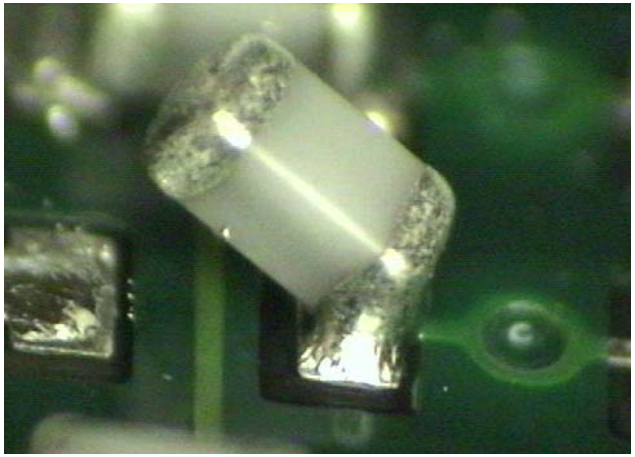
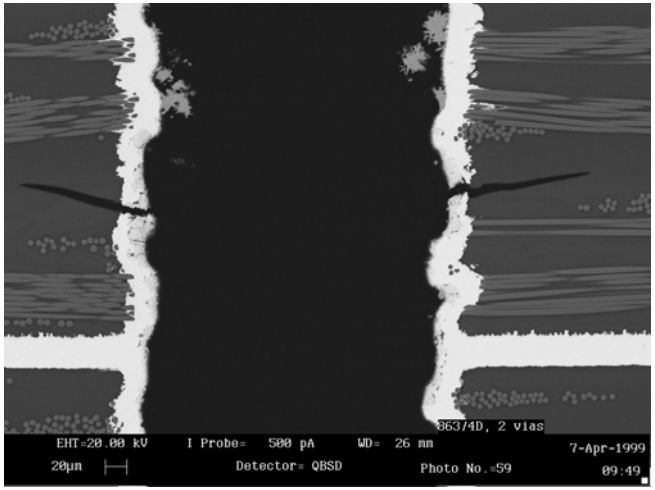
Sources of Manufacturing Complexity

Defects more likely with Lead Free solders *

- Poor wetting
- PCB warping
- Conductive anodic filaments



- Tomb-stoning



- Cracks in plated through holes
- De-lamination of multi-layer PCBs

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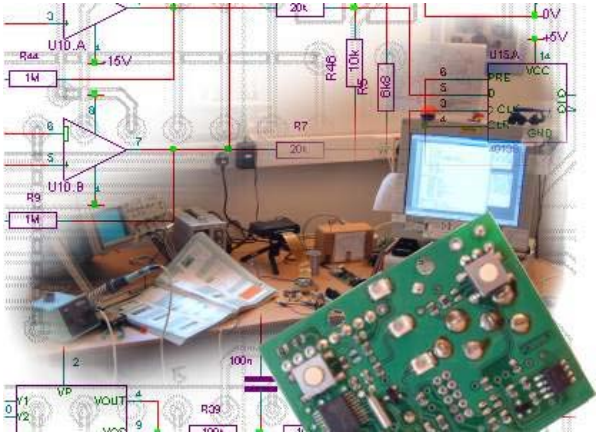
Component Pricing

- Mixed pricing strategies are being used
- Sales volumes are initially low on Pb-free parts, but these are climbing steadily as commercial customers convert.
- Sales volumes will decrease on Pb parts going forward.
- Some suppliers are implementing policies to prevent Pb parts from being returned.

Identifying Material Content Across Your Supply Chain is Now Critical to Ensure Compliance

Two key areas to consider….

Design / Development



- AVL
- Sustaining bom's
- Development bom's
- Supplier / technology roadmaps

Materials / Production

- Existing inventory
- Pipeline inventory
- Material handling requirements
- Mfg process compatibility

Challenges of Regulations Compliance

Materials Declaration Management standards: IPC 1751 / 1752

– A joint effort of:
  – The IPC (Declaration Process Management Subcommittee)
  – The International Electronics Manufacturing Initiative (iNEMI)
  – RosettaNet

- **Approved in January 2006**
  – ANSI standards certification will take more time.

Provides a uniform data format for exchanging materials composition data
- Defines required and optional fields
- Forms, based on Adobe PDF forms technology, can be printed or exchanged electronically.
- Data can be exchanged in standard XML format, conforming to RosettaNet PIP 2A13 (Distribute Material Composition Information) and 2A15 (Request Material Composition Information)
- References the "Material Composition Declaration Guide," commonly referred to as the Joint Industry Guide (JIG-101), to define the specifics of what needs to be reported (substances and methodology).

Suppliers involved in 2Q05 pilots with OEMs and/or CMs:
- Agilent
- Coherent
- Delphi
- Freescale
- Maxtor
- Motorola
- Teradyne
- TI

Challenges of Regulations Compliance

Materials Declaration Management standard: IPC-1752 (CONT'D)

- Establishes six classes for declaration of materials and processes
  - Accomplished by using a specific form related to the particular class

Class	Description	Form Type	Declaration Type From Top-down	Detail Requirements
Class 1	RoHS reporting at a homoegeneuos level in yes/no format	IPC-1752-1	RoHS Only	
Class 2	RoHS reporting at a homoegeneuos level in yes/no format and manufacturing information.	IPC-1752-1	RoHS and Manufacturing Information	
Class 3	RoHS reporting at a homoegeneuos level in yes/no format and JIG level A&B at the homogeneous level and other substances at the part level.	IPC-1752-1	RoHS and JIG Substances	IPC-1752-3 Users Guide
Class 4	Same as Class 3 with the addition of manufacturing information	IPC-1752-1	RoHS, JIG Substances and manufacturing information	
Class 5	RoHS reporting at a homoegeneuos level in yes/no format and JIG level A&B at the homogeneous level and other substances at the homogeneous level.	IPC-1752-2	RoHS and JIG Substances and Other	
Class 6	Same as Class 5 with the addition of manufacturing information	IPC-1752-2		

A 3Q05 Arrow survey of 85 component manufacturers indicated 25% would support such a standard

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Challenges of Regulation Compliance

Regardless of Standards – Some Component Manufacturers are reluctant to provide documented substance information

- Substance detail may be highly proprietary information
- Specific substances (in terms of weight and ppm) may vary from manufacturing site to manufacturing site
- Specific substances may vary between production lots
- The IT and human resource infrastructure required to report the levels of environmental data being requested is still being scoped and strategies are being discussed.

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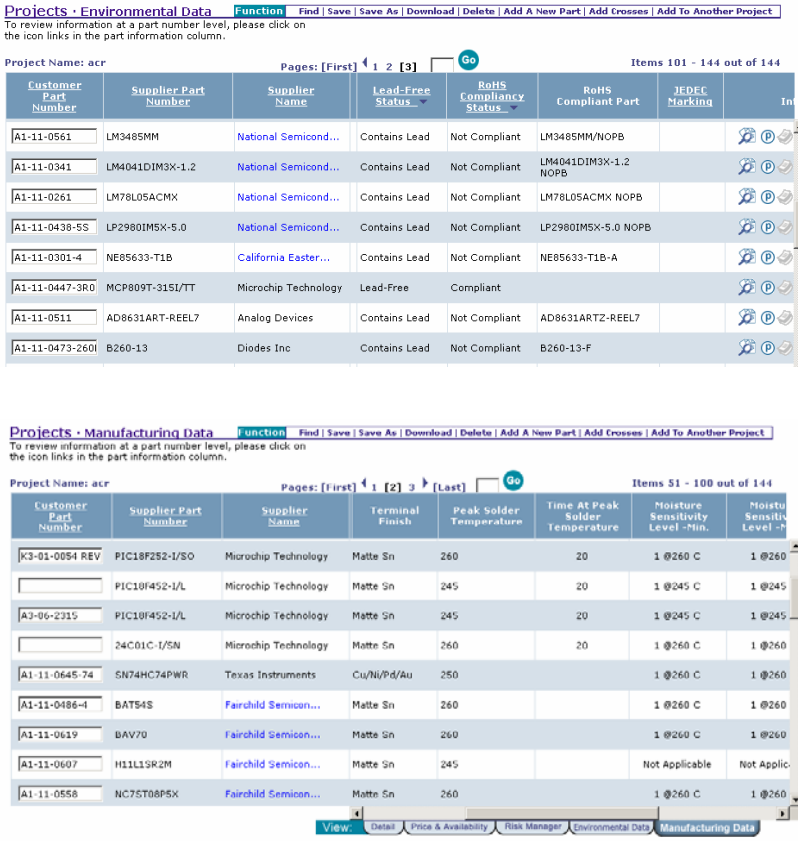
Why Component Information Services?

- **Assessing the compliance status of existing BOMs and identifying compliant alternatives (with fresh/current information) is a critical step in moving to, and sustaining, RoHS compliance.**

- **The rate of End of Life and Product Change Notices related to RoHS compliance exceeds activity ever seen by industry before.**

- **Missing a key supplier announcement related to a component you require (either Pb or Pb-free) can carry serious manufacturing and reliability implications.**

- **Attempting to track supplier roadmaps for part status, part numbering schemes, terminal finish choices etc. via web research and spreadsheets is time consuming and risky.**



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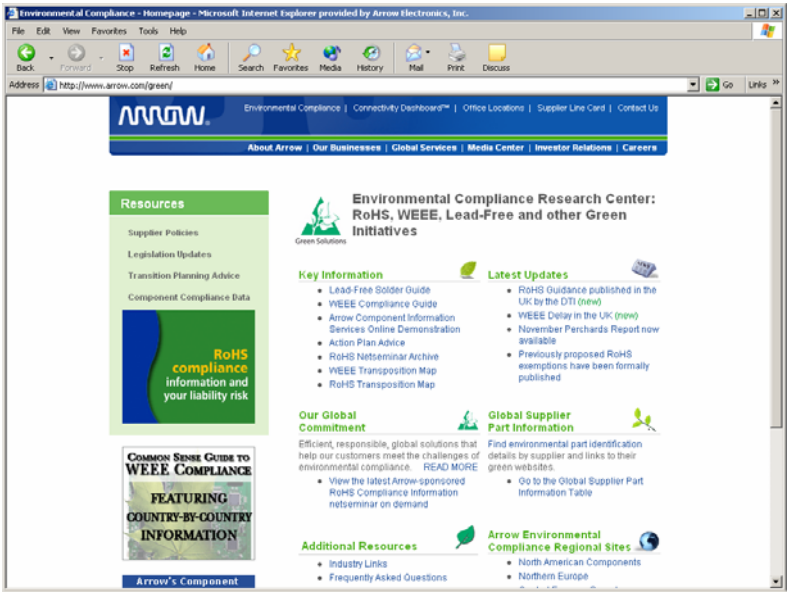
Q & A

Additional sources of information:

www.arrow.com/green



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