Confidence in Your Environmental Compliance

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Introduction

External forces have historically had a profound impact on the internal processes of companies. Organizations that have been able to modify their internal processes quickly and appropriately to align with external forces have enjoyed rewards such as competitive advantage, lower costs and higher profits. Companies are already quite familiar with the traditional external forces of competitive threats, shifting supply chains and changing customer demands. Now they must educate themselves and respond to new external pressures that pose both great risk and opportunities for them—environmental regulations. Companies that truly understand the reasons for and implications of these new laws have the best chance of successfully realigning their internal procedures to meet legal requirements, lower their risk and thrive in this era of expanded environmental regulations.

As we look at industry today, we see companies transitioning from learning about the European Union's (EU) environmental regulations to needing to address many other regulations evolving around the world, including those in California, China and Japan. Companies are moving from sourcing simple compliance for the parts and materials they use to developing sustainable environmental use models that incorporate due diligence and allow them to obtain the necessary information to power them. Company approaches to obtaining information are gaining sophistication to include an array of techniques including:

- Direct sourcing of environmental information from suppliers
- Physical lab-based verification to ensure sourced information is correct and filling gaps when manufacturers don't provide the needed information
- Use of in-field XRF testing to screen parts and materials as they are received to ensure expected material composition

Much work has been conducted in several areas related to environmental compliance recently, including the development of standards for sourcing material composition content (IPC-1752), standards for certifying products and processes (Industrial Environmental Quality Committee -IECQ), the creation of tools to manage content and roll up material content to report at the finished product level, and refinement of X-Ray Fluorescence technologies to provide in-field testing for hazardous substances.

This paper surveys the environmental landscape to provide an overview of environmental regulations around the world focusing on recent developments. It then projects those regulations onto corporations to identify and detail the internal use models needed to confidently support those regulations with appropriate due diligence. Finally, it details the best ways to obtain the data needed to drive the use models. When companies choose to support a regulation and use a model-driven approach, they can be confident in their compliance and successfully substantiate it.

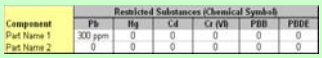
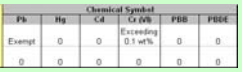
Environmental Regulations around the World

Environmental regulations are evolving quickly around the world. Below is a summary of some of the major regulations and how they compare with one another.

Table 1 – Regulations around the world

	EU-RoHS	China-RoHS	Japan
Regulation / Directive	Restriction of Hazardous Substances **2002/95/EC**	Management Methods for Controlling Pollution by Electronic Information Products **Ministry of Information Industry Order #39**	Marking for Presence of Specific Chemical Substances for Electrical and Electronic Equipment **JIS C 0950:2005**
Language	Many (all EU languages)	Chinese	Japanese
Legislation	Each EU country transposes directive into their country-specific laws	National	National
Restricted Substances and maximum concentration values (MCV)	Pb 1000 ppm Hg 1000 ppm Cd 100 ppm Cr VI 1000 ppm PBBs 1000 ppm PBDEs 1000 ppm	Pb 1000 ppm Hg 1000 ppm Cd 100 ppm Cr VI 1000 ppm PBBs 1000 ppm PBDEs 1000 ppm	Pb 1000 ppm Hg 1000 ppm Cd 100 ppm Cr VI 1000 ppm PBBs 1000 ppm PBDEs 1000 ppm **This is a labeling and disclosure requirement NOT a substance restriction or ban.**
Effective Date	**July 2006**	**March 2007:** Marking and Disclosure **Late 2006:** Publication of Catalog with specific covered products **Date TBD:** Actual substance restrictions and certification requirement	**July 2006:** Marking and Disclosure
Categories / Products	**8 Broad Categories** 1) Large Household Appliances 2) Small Household Appliances 3) IT and Communications Equipment 4) Consumer Equipment 5) Lighting Equipment 6) Electrical and Electronic Tools (except large scale stationary industrial tools) 7) Toys, Leisure and Sports Equipment 10) Automatic Dispensers **Categories Specifically NOT Covered:** 8) Medical Devices 9) Monitoring and Control Instruments	**11 Specific Categories Electronic Information Products** 1) Electronic Radar 2) Communication Equipment 3) Broadcast TV Equipment 4) Computers 5) Household Electronics 6) Electronic Measurement and Instruments 7) Electronics Industry Manufacturing Equipment 8) Electronic Components 9) Electronic Devices 10) Electronic Application Products 11) Electronic Professional Use Material Products Forthcoming catalog will specifically identify products in the broad categories above.	**8 Specific Electric Products** 1) Personal Computers (CRT & LCD) 2) Unit-type Air Conditioners 3) TVs 4) Microwave Ovens 5) Clothes Dryers 6) Refrigerators 7) Washing Machines 8) Copying Machines
Exemptions	Many existing exemptions; for example, lead in high melting temperature solders; lead as a alloying element in copper containing up to 4% lead , lead used in compliant pin connector systems, etc. Many other exemptions under review Formal process for requesting additional exemptions	No exemptions. It is expected that items that require exemptions (no alternative technologies) will simply not be covered in the catalog. However, many in industry anticipate at least some of the EU-RoHS style exemptions. There is no process to petition for an exemption	Several.
Out-of-scope considerations	Electronic components used in out-of-scope categories such as medical devices are out-of-scope. For example, use of Pb in a capacitor in a heart-pacemaker is out-of-scope.	Electronic components are in-scope even if used on out-of-scope categories such as toys. For example, a capacitor used in a toy must be compliant.	Not applicable

Table 2 – Regulations around the world (continued)

	EU-RoHS	China-RoHS	Japan
Labeling Requirements	None specific to RoHS; however sister regulation WEEE requires date of manufacturer and use of the image below: 	Mandatory Labeling: Non-Compliant Number signifies environmental safety period, number of years before product poses risk  Mandatory Labeling: Compliant but contains restricted substances in exempt applications Number signifies environmental safety period, number of years before product poses risk  Mandatory Labeling: Compliant 	Mandatory labeling (red label) for products that exceed threshold levels for six hazardous substances.  Optional labeling (green label) for products that don't exceed threshold levels for six hazardous substances or are exempt. 
Disclosure	Guidance indicates manufacturers must be able to produce technical evidence demonstrating compliance. This could include part-level disclosure of restricted substance content and associated compliance information.	Mandatory Disclosure when exceed thresholds 	Mandatory Disclosure when exceed thresholds 
Declaration / Certification	Self declare compliant by putting on market	Certification: Inspected at entry port; China Compulsory Certification by accredited lab in China. 	Self declare
Enforcement	Each individual EU country (25) responsible	China national agencies	
	May be sampled from market; manufacturer to provide technical documentation demonstrating compliance; may be subject to analytical testing	Certification: Inspected at entry port; China Compulsory Certification by accredited lab in China.	
Applicable Standards	IPC-1752, JIG-101, IECQ 080000	IPC-1752, JIG-101, IECQ 080000	JIS C 0950:2005, JGPSSI
Comments	Amendments: 2005/618/EC : Establishment of MCV 2005/717/EC: Exemptions 2005/747/EC: Exemptions	Requires translation and reporting in Chinese	Requires translation and reporting in Japanese Japanese industry has been very proactive through their use of the JGPSSI (Japan Green Procurement Supplier Survey Initiative) that covers 29 hazardous substances. Virtually all Japanese manufacturers follow JGPSSI requirements as a matter of principle and honor.

Trends in Global Compliance

Manufacturers have been studying the best ways to address the differing environmental requirements of regional markets around the world. These requirements can be due to state, national or supranational regulations, competitive pressures and specific customer requirements. Companies that sell to only a few major markets have considered supporting separate similar products to each market. But this gets complicated quickly, involving separate inbound and outbound inventories for each region and separate production lines—perhaps separate lead-based and lead-free production lines, different Bills of Materials (BOMs), different compliance documentation and so on.

Many companies have decided to take the least common denominator approach and design their products to be compliant with environmental regulations and customer requirements regardless of where they ultimately are imported. This way, the already complicated compliance process is simplified. Companies track and compile regulations in the regions they sell and then set up internal processes to ensure only parts and materials that comply with this superset are used.

One useful resource for this information is the Joint Industry Guide (JIG-101) that was last updated in April 2005. This guide represents a collaboration between ECITA (originally European Information & Communications Technology Association, now know only as ECITA), EIA (US-based Electronics Industries Association), JEDEC, and JGPSSI (Japan Green Procurement Supplier Survey Initiative). The guide offers a comprehensive listing of substances known to be legislatively banned, restricted or that must be reported—Level A; and substances industry has identified as substances of concern and are relevant for reporting—Level B. Using the JIG as a basis for hazardous substance collection is a forward-looking approach many companies are adopting.

Compliance Responsibility and Enforcement

It is the responsibility of the producer to ensure its products are compliant. In the EU, producers implicitly self-declare their compliance by placing products on the market. In the UK, according to UK DTI guidance, producers have the burden of demonstrating compliance by providing satisfactory and appropriate evidence such as technical documentation. This evidence can take the form of material declaration information collected from manufacturers, test results and other relevant information. In the UK, enforcement falls to the National Weights and Measures Laboratory, who may purchase products on the market and subject them to materials testing and request evidence of compliance.

It should be noted that each country in the EU is responsible for transposing EU RoHS regulations into its own laws, arranging enforcement and penalties. It is generally regarded in the industry that UK DTI is providing leadership in the area of guidance and that most EU countries will adopt similar positions.

Other regions of the world such as China will likely have vastly different approaches. China has already indicated it will eventually require physical testing and certification before releasing products from mandatory customs processes.

Due Diligence and Its Applicability

One of the guiding principles that emerged from the EU's RoHS Directive is the concept of the Due Diligence Defense. The UK's Department of Trade and Industry (DTI) explains this in their Guidance Document as being able *…to show one took all reasonable steps and exercised due diligence to avoid committing an offense. This may include an act or default or information given by a third party…*

So what are reasonable steps? The guidance document provides a flow chart that outlines some of the steps to consider in this area and to give some insight into when testing to determine material composition is advisable. We've reproduced the chart here (with interpretation) and color-coded it to indicate steps associated with data collection, material composition analysis, user decision points and decisions that can only be made with industry expertise in material composition. See the following figure and discussion on these areas.

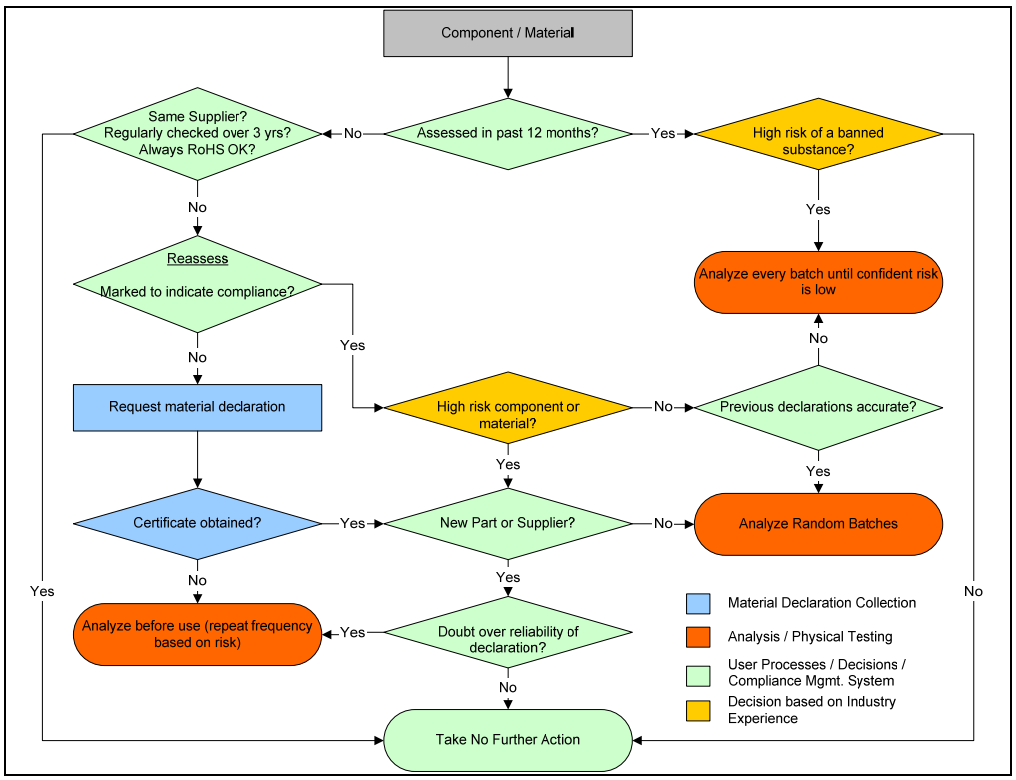


Figure 1 - UK DTI-Based Compliance Processes

Material Declaration Collection: These blocks refer to the collection of overall compliance information and substantiating information such as maximum concentrations of the six RoHS (in this case) substances. This type of information should be collected for all parts and materials used. However, it should be noted that obtaining this information in a timely fashion is not always possible. Recent industry experiences show that companies can expect to be able to collect this information only on 80-90% of their parts. Some manufacturers are getting better at providing this information, but many continue to struggle. As manufacturers better understand the information requirements, adopt industry standards and deploy automated systems, response rates should improve significantly.

Analysis / Physical Testing: These blocks indicate testing processes to determine the presence and maximum concentration levels of the restricted substances. A thoughtful approach to testing is encouraged with the performance of testing that makes sense for suspected substances in given homogeneous materials. For example, since it wouldn't be expected to find PBDEs in rolled steel, testing would not be performed for this. Also, use a test approach taking advantage of an appropriate mix of test methods at your disposal, such as lab-based analytical testing and XRF-based testing.

User Processes / Decision Points / Compliance Management Systems: These blocks indicate company decision points based on company interactions with manufacturers and internal processes (part accessed in last 12 months; other certificates from the supplier accurate, etc.). This information is best maintained in a compliance management system. There are commercial applications for this function from dedicated providers as well as from Product Lifecycle Management (PLM) and Enterprise Resource Planning (ERP) providers with separate modules.

Decision Based on Industry Experience: These are points at which an informed decision can only be made based on specific knowledge of material composition for different types of parts and materials. This knowledge continues to be collected based on the results of broad testing and material declaration collection. For example, a company specializing in material composition collection builds up profiles of parts with a relative occurrence of each restricted substance in specific types of parts. A testing company does the same through their testing experience. This information is critical when it is based on information from thousands of manufacturers and hundreds of different part types.

We can drill down and expand the diagram (again, our interpretation) to see how lab-based analytical and XRF testing could be incorporated.

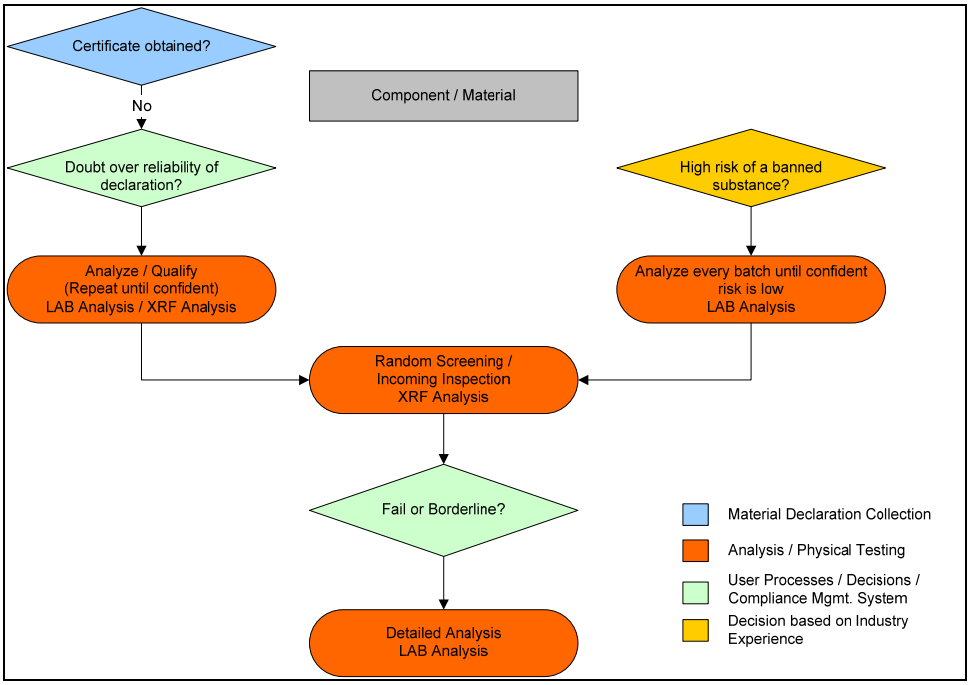


Figure 2 - Use of Testing and Screening for Due Diligence

If there's a high risk of the presence of a restricted substance, you may opt for lab-based or XRF-based analysis depending on available sample size, suspected substance, suspect location of substance in homogeneous material and relative risk. As discussed later, XRF and lab-based analysis each have their strengths.

The information presented in this section is useful in determining needs for European Union RoHS compliance, but other geopolitical regions may have very different requirements. For example, China has indicated that it will eventually require certification through a Chinese testing laboratory. In this case, you would want to exercise due diligence to ensure your product doesn't have restricted substances, but as part of your product release process, you would also need to have your product "certified."

Use Models

The best way for companies to determine what information they need to collect for compliance is to look at the use models they need to support. When the EU RoHS regulations were first passed, many companies started asking suppliers if their parts were "compliant." If they were told that the parts were in fact compliant, manufacturers continued to use them. But the thinking of most of these manufacturers has changed radically. They are now sourcing information that supports their suppliers' claims of compliance, offers manufacturing process compatibility, provides supply chain management and lifecycle information and maintains a foundation for their due diligence processes and external reporting requirements.

To get a good understanding of what information companies should be collecting and maintaining, let's look at some of the major use models that need to be supported.

Table 3 - Major compliance-related use models

Use Models and Tasks	Description and Purpose	Needed Content to Support Use Model	Method to Obtain Content and Comments
Track environmental regulations	Regularly check on legislation passed in regions your products will be sold in Capture regulations and transform to business rules to allow a product analysis to be run against different regulations and or customer requirements	Regulations for each region you cover	Track regulations by visiting government-provided websites or use a commercial service Note: In many cases, regulations aren't published in English and can be difficult to track on your own.
Obtain compliance information from suppliers	Determine compliance information needed for tracking Utilize a methodology to obtain and maintain the information, and source this information from your suppliers (web, surveys, material declarations, etc.). Typical information needed is: overall EU compliance, maximum concentration levels for six RoHS substances, total weight of substances, certificates of compliance, testing results, etc.	This information is needed to ensure compliance, enable substance roll-up analysis, material declaration reporting and for responding to allegations of non-compliance.	Electronic part manufacturers are being inundated with requests and are now very familiar with EU-RoHS. Many have needed compliance information—in various formats—on their websites. Various providers of non-electronic parts are not familiar with the regulations and require time to understand and provide the needed information. Companies can source this information on their own, but have often significantly underestimated the necessary resources. Commercial parties specialize in this area and provide initial and maintaining services. Some parts may require testing when the information cannot be obtained or there is not confidence in the supplied information. Commercial services provide a variety of testing services.
Maintaining compliance information from your suppliers	Since new regulations are being introduced, existing ones continue to evolve, manufacturer parts change and manufacturers are able to provide better and deeper information. It is essential to track this information. Manufacturers provide a significant amount of compliance (lifecycle) information via Product Change Notices (PCNs), so these should be tracked.	Ongoing analysis as above PCNs often contain compliance and lifecycle information.	In addition to the above, companies should sign up to individual manufacturer services to obtain PCNs and End of Life (EOL) notices or rely on commercial services that provide this as part of their reference databases and targeted services.

Use Models and Tasks	Description and Purpose	Needed Content to Support Use Model	Method to Obtain Content and Comments
Managing compliance information associated with your products	A management system is needed to store and maintain sourced information where it can be easily accessed for engineering part lookup and detailed BOM analysis.	Part information utilized in management use models	There are dedicated Compliance Management Systems that integrate with existing corporate systems. PLM vendors have also been introducing modules for their systems that provide this capability. Companies can also develop these systems themselves, but there is much data modeling needed to correctly support all the necessary use models.
Ensure manufacturability of your products	Besides ensuring environmental compliance, it is critical to make sure the compliant parts you purchase are compatible with your compliant processes. For example, lead-free soldering requires significantly higher temperatures than lead-based (non-compliant) solders, and some compliant parts are not able to withstand these higher temperatures.	For solderable electronic parts: maximum processing temperature and MSL (moisture sensitivity levels) at that temperature	Source this information from the manufacturer's website or directly from the manufacturer. Commercial services offer this information through reference database and targeted services.
Know how to identify and order your compliant or non-compliant parts	There's been a lot of controversy over how component manufactures indicate compliant versions of previously non-compliant parts. Many are issuing new part numbers, but some are keeping the part numbers the same and going by date codes to determine compliant/non-compliant versions.	Source identification of compliant part (part number or date code) and the corresponding part number or date code	Source this information from the manufacturer's website or directly from the manufacturer. Commercial services offer this information through reference databases and targeted services.
Support engineering part research and selection	Engineers need to search corporate preferred parts lists and external sources for parts to use in their products, and they need to make sure the parts are compliant with regulations and compatible with manufacturing processes.	Internal and external part catalogs with detailed technical characteristic, compliance, manufacturability, supply chain and lifecycle information	There are dedicated Component and Supplier Management systems that integrate with corporate systems to support internal preferred parts lists. PLM vendors have also been introducing modules that provide this type of capability. There are also reference content databases that provide this type of information, especially for electronic parts.
Confidence in supplied information	A critical piece of compliance is determining your trust level in supplier-provided compliance information. When trust is low, additional steps should be taken to assure compliance such as requiring physical testing.	The method of determining compliance for parts or materials such as engineering estimates, physical testing, regular monitoring of suppliers	Source this information directly from suppliers. When unavailable, consider performing testing yourself.

Use Models and Tasks	Description and Purpose	Needed Content to Support Use Model	Method to Obtain Content and Comments
BOM Management and Analysis	This is a system where all the pieces come together. That is, the tracked regulations are represented as business rules; all corporate approved parts have material composition, compliance and other related information, and BOMs are loaded to run analysis on. This BOM analysis can be with respect to overall compliance, manufacturing compatibility, material declaration generation or generating a report as part of the product release process or responding to an allegation of non-compliance.	All compliance information	There are dedicated Compliance Management Systems that integrate with existing corporate systems. PLM vendors have been introducing modules for their systems that provide this capability. Companies can also develop these systems themselves, but there is much data modeling and reporting capabilities needed to support all the necessary use models.

Table 4 - Non-Traditional compliance-related use models

Use Models and Tasks	Description and Purpose	Needed Content to Support Use Model	Method to Obtain Content and Comments
For defense, aerospace and high-reliability companies	Often, companies that manufacture high-reliability products for defense and aerospace need to ensure their products DO contain lead in the terminal finishes. It's a use model that opposes compliance, and it's critical to these companies.	Terminal Finish	The same type of sourcing is required for these companies, but the use is much different. It is also advised that companies perform rigorous incoming inspection screening to ensure lead-free versions aren't inadvertently shipped in. One manufacturer indicated that about 14% of parts received that were supposed to be lead-based were actually lead-free parts—a serious and potentially dangerous issue (due to tin whiskering concerns with Pb-free parts—especially in aerospace and defense applications.)
Defense contractors support of Berry Amendment; Specialty Metals Clause	With the debate over the Defense Spending Bill of 2007, US defense contractors are facing the prospect of ensuring all specialty metals (titanium, certain steel alloys, etc.) used are originally from US firms.	Country of origin for specialty metals in products	Defense contractors should continue to monitor this as it develops to determine if they'll need to support this or not. This requirement would certainly move in the direction of full—or at least fuller— disclosure.

The following table shows the evolution in the information companies have been requesting (and after a lag, the information suppliers have been supplying) and how the information is used.

Table 5 - Data Availability and Use Models Enabled

Content and Enabled Capabilities Timeline						
Year / Content	2004	2005	2006 Today	2006 2nd Half	Primary Capabilities Enabled	
RoHS Y/N	▪	■	■	■	Compliance	
Substance Levels (RoHS)	▪	■	■	■	Reporting / Material Declarations	Substantiate / Confidence
Manufacturing Info		■	■	■	Manufacturing Compatibility	Reliability, Handling
Replacement Part		■	■	■	Supply Chain Logistics	Avoid E&O Inventory
Substance Levels (JIG)		▪	■	■	Global Compliance	Reporting / Material Declarations
Testing part of Program		▪	▪	■	Confidence	Part Coverage
Screening Parts (XRF)		▪	▪	■	Avoid Contamination	Confidence
Certificate of Compliance		▪	▪	■	Substantiate/Confidence	Liability
Part Profiling			▪	■	Identify candidate parts for verification	
Full Disclosure			▪	▪	Global Compliance	Reporting / Material Declarations

To get an idea of the information companies require, see the following listing that shows the critical attributes. It should be noted the information shown here aligns with the information requested on the IPC-1752 standard discussed later.

Table 6 - Necessary Attributes to Enable Use Models (for solderable electronic parts)

	Reference Databases and/or Content Sourcing Services (RoHS + JIG A/B)	Physical Testing Services
Key Compliance Attributes		
RoHS Compliant (Yes/No)	●	
Lead Free (Yes/No)	●	
RoHS Exemption(s)	●	
Item Weight (mg)	●	
Disclosure Date	●	
Processing Attributes		
Terminal / Contact Finish	●	
JESD-97 (Code)	●	
Contact Material (Connectors)	●	
Peak Reflow Temperature	●	
Time @ Peak Reflow Temperature	●	
MSL @ Peak Reflow Temperature	●	
Tin Whisker Mitigation Strategy	●	
Lifecycle and Compliant Replacement Part		
Planned years-to-end-of-life (YTEOL)	●	
RoHS-complaint Number (replacement part)	●	
RoHS Identifier (MPN, date code, lot code)	●	
Date Code of Compliant Part (when MPN's are same)	●	
Planned Availability of Compliant Part	●	
Documents		
Product Change Notices and Datasheets	●	
Certificates of Compliance or similar	●	
RoHS: Substance Concentrations and Weights		
Lead (concentration and weight)	●	● & report
Cadmium (concentration and weight)	●	● & report
Mercury (concentration and weight)	●	● & report
Hexavalent Chromium (concentration and weight)	●	● & report
PBB's (concentration and weight)	●	● & report
PBDE's (concentration and weight)	●	● & report
Joint Industry Guide: Substance Concentrations and Weights		
Level A Substances 9 additional substances (concentration and weight)	●	● & report
Level B Substances 9 additional substances (concentration and weight)	●	● & report

Obtaining Compliance Information and Ensuring Its Accuracy

Obtaining high-quality compliance information is one of the biggest challenges facing manufacturers of electronic products today. There are two main ways of obtaining information: by sourcing (directly or indirectly) from the manufacturer or by performing tests. In this section, we'll review the various strategies for collecting compliance information and outline a best practice approach that combines the strategies.

Obtaining Manufacturer Part Compliance Information

The core of any compliance program revolves around having compliance information on the parts and materials used in products. This information is needed when determining the compliance of existing products, designing new products - What parts are compliant that fit my design criteria? - and during the analysis and reporting process—that is, demonstrating and documenting the parts used are compliant. (As discussed earlier, other information is needed as well such as availability, lifecycle, manufacturability, etc.)

In the design phase, engineers are looking first at parts that have been internally qualified and identified as approved or preferred parts. Traditionally, these have been the best parts to use since there is no need for additional qualification. The parts are well-known, and there are existing volumes and pricing with the suppliers. However, the advent of environmental regulations has changed everything. All of those preferred parts now need to be re-examined to determine that they are compliant, compatible and available. If a part is non-compliant, incompatible or unavailable, then a compliant replacement part is needed. Industry is finding that about 48% of parts in existing systems and products are non-compliant. Of those, the manufacturer provides a compliant replacement about 75% of the time. So for an effective internal catalog, companies need to ensure they have compliance information on all active parts in their catalog. Non-compliant part entries should include suitable compliant replacements.

If designers can't find a needed compliant part in the internal catalog, they must use other sources. These sources include individual manufacturer websites or commercially available reference databases. Reference databases aggregate targeted information from many manufacturers, standardize them and provide a graphic user interface to access the

information. Reference databases have expanded in recent years to include detailed compliance, manufacturability, availability and lifecycle information. To date, most reference databases target electronic parts.

The websites of electronic part manufacturers have improved markedly over the past year, with most manufacturers providing at least basic EU-compliancy information and a few—but growing in number—offering fairly detailed information needed to drive customers' use models. However, there is still a lack of standardization of compliance information between manufacturers, and each provides information to a different depth. Obtaining the needed information for all of your manufacturers requires some level of direct sourcing from them.

Regardless of where information is gathered from, companies need to ensure they collect the information required to drive their compliance use models. They need to make sure their compliance management system can accommodate and use the collected information and that they arrange to distribute the information to other systems in the organization that require the information. A typical distribution by function would be:

- Component and Supplier Management/Product Lifecycle system: overall compliance information to support part selection and new part introduction
- Manufacturing Information system: compliance, marking and identification, maximum processing temperatures, MSL levels indicating treatment of electronic parts before and during manufacturing, terminal finish and tin whisker mitigation strategy
- Compliance Management system: All information for collection and tracking, running BOM analysis, and generating reports

To collect information, manufacturers typically turn to a template or survey form they send out to manufacturers requesting the needed information. With few standards until recently, manufacturers have been fielding hundreds of different templates requesting the information. Indeed, manufacturers often would get requests from the same company for the same parts with newer versions of templates with more information requested as companies realized they needed to drive more use models or that they had interpreted a regulation incorrectly. Usable standards are now starting to be adopted, and there is great optimism that standards will ease the sourcing crunch (see next section).

It takes a surprising amount of resources to source the needed information. Most companies find they need assistance in this area—whether in the form of services providers or tool providers that can automate some steps of the process—or both.

Regardless of the method of collection, it is important to ensure the information fulfills compliance requirements. This is a relatively straightforward task and entails ensuring information provided is complete (all critical fields filled out) and consistent—consistent in the sense valid values for attributes are used and related information fields logically agree with each other. For example, if a part is identified as RoHS-compliant, but the Terminal Finish is SnPb (tin lead) and Pb concentration is 300,000 ppm, there's a problem. In this case, several of the attributes seem to indicate the part would be non-compliant, which is inconsistent with the overall compliant status. These issues require clarification cycles with the manufacturer.


DET NORSKE VERITAS
MANAGEMENT SYSTEM CERTIFICATE
IHS PARTS MANAGEMENT PVT. LTD.

Figure 3 - Sample ISO 9001 Certificate

Since the information collected through the sourcing process may come under legal scrutiny if a company is ever faced with an allegation, it is important to keep an audit trail of the information collected, including how and when it was collected. This audit trail could serve as an important piece in demonstrating reasonable due diligence.

Companies should consider certifying their processes under ISO 9001 through an accredited third party or using the new IECQ standards discussed below.

The Role of Standards

Standards make the job of collecting environmental compliance, hazardous substance, material composition and necessary related information much easier. The recently approved IPC-1752 standard has done a good job at identifying

the necessary information needed to drive a company's use models—especially for solderable electronic components (terminal finish, maximum processing temperature, etc.). The IPC standard supports different levels of disclosure from overall RoHS compliance - to manufacturing compatibility information - to full material composition disclosure. It includes a digital sign-off block that when used, establishes the document as a Certificate of Compliance.

One drawback of the current standard is that it supports a single part at a time. That is, a separate file is needed for each manufacturer part sourced. For some companies with hundreds or thousands of different parts from a single manufacturer in their preferred parts lists (PPL), hundreds or thousands of IPC-1752 files could be needed. The IPC recognizes this requirement and is working on a multi-part standard. This will be an important standard to monitor as it evolves.

There are other types of standards available as well. The JIG-101 discussed earlier is very useful in identifying the substances of concern that manufacturers should be tracking, whether currently restricted (Level A) or identified as a risk substance that should be tracked. Many companies are using the JIG (Level A and B) as the basis for identifying their hazardous substance collecting and reporting requirements to prepare them for future compliance regulations.

Physical Verification

Introduction

An important part of any compliance strategy is analytical testing for restricted substances. Analytical testing consists of using chemical analysis to determine the material composition of a component. It typically includes obtaining samples, sample preparation, actual testing using mass spectroscopy or other analytical techniques and reporting results. Although it is prohibitively expensive (time, cost, destructive nature) to entertain 100% testing of homogeneous materials for anything other than the simplest of products, the strategic use of analytical testing significantly reduces the risk of non-compliance.

Before performing analytical testing, users should perform risk analysis to expose their products' highest risk components. Determine candidates for analytical testing when:

- The part or material is historically known to have contained a restricted substance
- You are unable to obtain compliance information on the part (and unable to find a suitable compliant replacement part)
- You successfully sourced material composition and compliance information, but you lack confidence in the information—perhaps due to a new vendor you have not worked with before or a vendor who has been known to provide erroneous information in the past
- XRF testing was performed on a material or part which yielded unexpected non-compliant test results when the material declaration indicated the part should be compliant; or when XRF testing yielded a borderline or inconclusive result

The best way to determine high risk components is to work with an experienced test provider and compliance information provider. Test providers have accumulated test results for a wide variety of parts and materials from hundreds of suppliers; compliance information collection providers have accumulated material declaration and compliance information from thousands of suppliers for millions of parts. Using this accumulated information, a picture emerges of the most likely parts and materials to contain restricted substances.

After high-risk components are identified, a decision must be made regarding which ones to test. To help with this, the components can be risk-prioritized and matched with available verification budgets. Initial budgets should allow for rigorously analyzing about 1% of components for restricted substance content then adjust each six months based on variation from expectations.

A considerable amount of work has been done in the past several years dealing with standardizing test methods for the RoHS substances: lead (Pb), cadmium (Cd), mercury (Hg), Polybrominated Biphenyls (PBB), Polybrominated Diphenyl Ethers (PBDE) and Chromium VI (Cr V1). Specifically, the global standards body International Electrotechnical Commission (IEC) has sought to standardize these test methods that culminated with the recent publishing of the IEC TC111 WG3 testing methods. These standard methods are under member review with final voting anticipated in October 2006. These methods are the most accurate test methods available and are the first set of industry-accepted standardized tests for the RoHS substances. It is anticipated these test methods would be used in enforcement of the EU-RoHS regulations. China is actively participating in development of these standards, and it is anticipated that China would adopt these testing methods for mandatory certification by a China Compulsory Certification (CCC) lab.

It's important to remember that even when suppliers have provided a declaration of compliance for a component, the risk analysis may suggest that analytical testing be performed on certain homogeneous materials to validate the declarations.

Use of Test Data and Obtaining a Certification Mark
Early in the supply chain, homogeneous materials are combined to make sub-components, then components, then assemblies and ultimately, final products. The greatest cost efficiencies are achieved when analytical analysis is performed on medium to high-risk homogeneous materials early in the supply chain. Results of this analysis can then be passed on through the supply chain. If testing—or fundamental formulation analysis—is not done early in the supply chain, the cost for confidently declaring compliance rises dramatically.

Figure 4 - Example Product Certification Mark

Test data can be used to declare a product compliant when one tests every homogeneous material in the product. This approach is a good choice for manufacturers who make components or products of limited complexity. For example, when this thorough RoHS testing is provided by Underwriter's Laboratories for an electronic component, UL awards a UL RoHS certification mark for the product. When a product has a small number of homogeneous materials, this is a sound approach (cost, time, risk). However, this is not a feasible approach for more complex products.

For complex products that often contain hundreds or thousands of components and materials, having confidence in compliance—and demonstrating appropriate due diligence—is the whole of supporting a compliant management system, performing risk analysis, collecting declarations from suppliers and some testing that demonstrates a functional compliance strategy. When a company takes this comprehensive approach, they may want to consider certifying their process rather than their product. See the section on process certification and IECQ standards below for more information.

Environmental Compliance—Process Certification
One unifying expectation has emerged with the WEEE and RoHS type legislation around the globe is that companies must have a good management system that can deal with environmental regulations. Indeed, the very process of due diligence will require proof of some management system.

In order to create an international standard for such a system, the IECQ (International Electortechnical Commission) developed the QC 080000 standard for Hazardous Substance Process Management. HSPM is a supplement to the familiar ISO 9001:2000 Quality Management System (QMS) framework. This new standard, when applied properly, will position companies to establish a compliant restricted substance management system. QC 080000 details that everyone involved in the manufacture of products understand the company's processes to identify, control, quantify and report on the hazardous substance content of their products. All processes must be well documented, consistently applied and allow the company to be responsive to requests to verify compliance.

In the United States, the standard is represented by the Electronic Industry Alliance (EIA) and Electronic Component Certification Board (ECCB) as the EIA/ECCB-954 standard. And like ISO 9001, companies can be certified to be IECQ QC 080000-compliant by a Supervising Inspectorate.

Figure 5 - Example Product Certification Mark

Keep in mind if one product was to come under RoHS regulatory scrutiny, perhaps one of the first questions companies would need to answer would be whether they have a compliance management system. QC080000 provides the framework for demonstrating this competence.

Lab-Testing Strengths and Relative Costs

Analytical lab testing success is defined by quality, speed and cost. The quality of work depends on the understanding and experience of the lab personnel, the ability to implement the internationally accepted standards, and on the commitment to excellence in the lab. Laboratories such as UL have made strong commitments to leadership roles in international standards committees that are developing and defining the test methods that have the best chance to be recognized as a high-quality test lab. Costs are driven down in lab work by performing the analytical testing in regions where labor costs are the lowest, such as Asia. There will always need to be some level of commitment to Research and Development so that a company can remain on top of the latest test methodologies for restricted substances. Additionally, new materials will emerge from legislation in the years to come. R&D will allow a company to stay prepared. XRF technology provides excellent analysis speed, is less costly and is a good choice for screening technology.

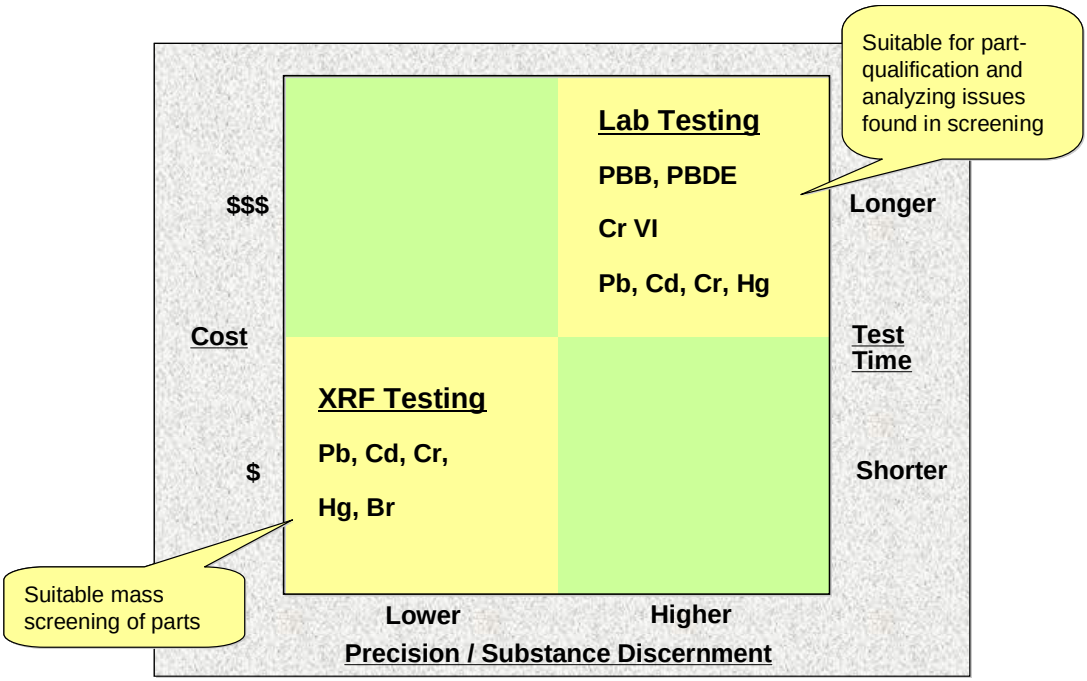


Figure 6 - Complimentary nature of lab-based and XRF analysis

XRF Verification

An important element of a complete compliance strategy is the sampling and screening of parts and materials during incoming receiving from external suppliers and internal inventories. This is the last chance to catch non-compliant parts before they end up on the production line— and ultimately in finished products. A relatively new and often portable technology called X-ray fluorescence—XRF for short—is being used for this function. XRF is also being used in some cases where analytical testing was used.

XRF Technology

X-ray fluorescence (XRF) analysis is based on the phenomenon of the emission of X-rays by the constituent atoms of a sample when excited by an external source of radiation. When a gamma- or sufficiently energetic X-ray, from an X-ray tube, impinges on an atom of the sample material, it may eject one of the inner shell electrons of the atom. The vacancy created is instantaneously filled by one of the electrons from the higher energy shell, as is schematically shown in Figure 7.

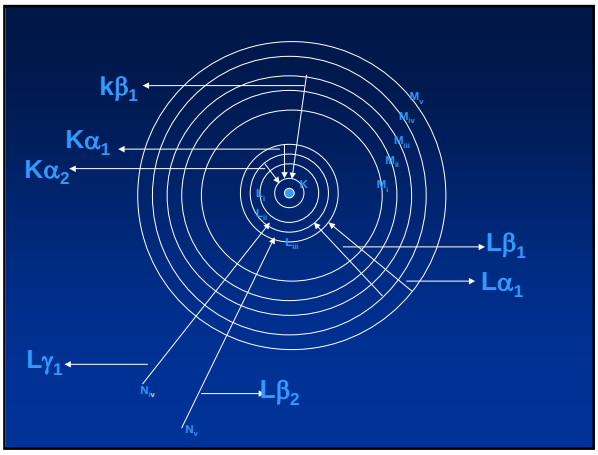


Figure 7 - Emission Lines for Characteristic Elements by X-Ray Fluorescence

The energy difference between the two energy shells involved in the process is released in the form of X-ray radiation. This radiation is called a characteristic X-ray because its energy is specific and unique to the emitting element (atom). By being able to measure the energy and intensity of the characteristic X-rays produced by individual elements, both qualitative and quantitative aspects of XRF analysis, respectively, are realized.

Figure 8 - Thermo Electron NITON Portable XRF Analyzer

XRF spectrometry has long been recognized as a comprehensive analytical tool. It is an advanced, low-cost, and repeatable analytical method, yet is one of the simplest analytical techniques available. It is truly multi-elemental (that is, it determines all elements in a sample simultaneously), offers a wide dynamic concentration range from limits of detection to 100% and can analyze all types of solids, liquids and powdered materials. The analysis is quick and usually does not require sample preparation. The advanced analytical algorithms are robust and have built-in a substantial degree of tolerance for variety of sizes and shapes of measured objects. An additional and unique attribute of XRF analysis is its nondestructive character, meaning the tested sample/object is not altered, defaced or destroyed—a feature that's useful when repeated analyses of a sample are necessary, or in situations involving litigation.

RoHS/WEEE Screening

When employing XRF technology in support of restricted substance compliance, there are two characteristics one must know—the limit of detection (LOD) and the accuracy of the device. The limit of detection tells us the smallest concentration that can be reliability detected. (That is, is the restricted substance present?) The device accuracy tells the margin of error for a given measurement.

These characteristics are dependent on the type of medium analyzed, complexity of its chemical makeup and measurement time. The table below shows LOD concentration (in ppm by weight) for typical plastic materials (matrix)

using a measurement time of 120 seconds per sample. We can see that the XRF devices characterized in the following table can reliably detect the presence of Pb in the samples when it exists in a concentration of 40 ppm or higher.

Table 7 - Limits of Detection (LOD) for Cd, Pb, Hg, Br and Cr in Plastics

Sample Material Matrix	Elemental Concentration Limits of Detection				
	Cd (ppm)	Pb (ppm)	Hg (ppm)	Cr (ppm)	Br (ppm)
	Cadmium	Lead	Mercury	Chromium	Bromine
	Cd	Pb	Hg	Cr VI	PBB / PBDE
PVC, 2%Sb (no Br)	18	16	20	20	12
PE, 2%Sb (no Br)	16	10	10	10	6
PVC, 2%Br (no Sb)	13	40	30	20	N/A
PE, 2%Br (no Sb)	30	30	15	10	N/A

It should be noted XRF provides results for the total amount of a specified element regardless of its chemical state. For example, since XRF cannot distinguish Cr VI from Cr III, when we measure Cr concentrations above the RoHS threshold level of 1000 ppm, we can't conclude that Cr VI is above the threshold value. In these cases, more detailed Cr VI-specific testing is needed. However, if total chromium reported by XRF is less than the 1000 ppm threshold, further testing is unnecessary since all chromium present—in any chemical state—must be below the threshold.

A similar situation may be seen with bromine which is a component of the restricted brominated flame retardants PBBs and PBDEs. Typically, bromine makes at least 30% of PBBs and PBDEs. Since XRF measures only total bromine content, readings above the 300 ppm threshold indicate the possibility of PBBs or PBDEs. The case calls for more detailed analytical testing.

Testing Strategy Using Portable XRF as a Screening Device

Hand-held analyzers can be extremely useful tools for incoming inspection screening. These instruments are portable, perform non-destructive analysis and are easy to use in the field. XRF is a valuable first phase of testing during which an assessment is made whether additional, lab-based analysis is required. For example, if a component is tested with the portable XRF analyzer and it is found that the lead (Pb) content is 2,800 ppm, this material can be safely rejected as non-compliant without the need for additional testing. Similarly, should the screening test produce a chromium (Cr) result equal to, say, 200 ppm, the material can be deemed to be compliant.

The chart below illustrates a proposed testing scenario in which the first line of testing is performed with a portable XRF analyzer. Based on the results obtained with portable XRF, a decision will be made whether the tested material is compliant or not with the RoHS requirements or whether the results are inconclusive and further testing is necessary. The acceptance threshold values for elements are set lower than the regulatory 100 ppm for Cd and 1000 ppm for the other 4 elements. This is to account for the inherent accuracy of measurement associated with the analysis of a possibly heterogeneous component. For example, the chart shows we set a range of 700-1,300 ppm as being inconclusive in asserting Pb concentration compliance or non-compliance.

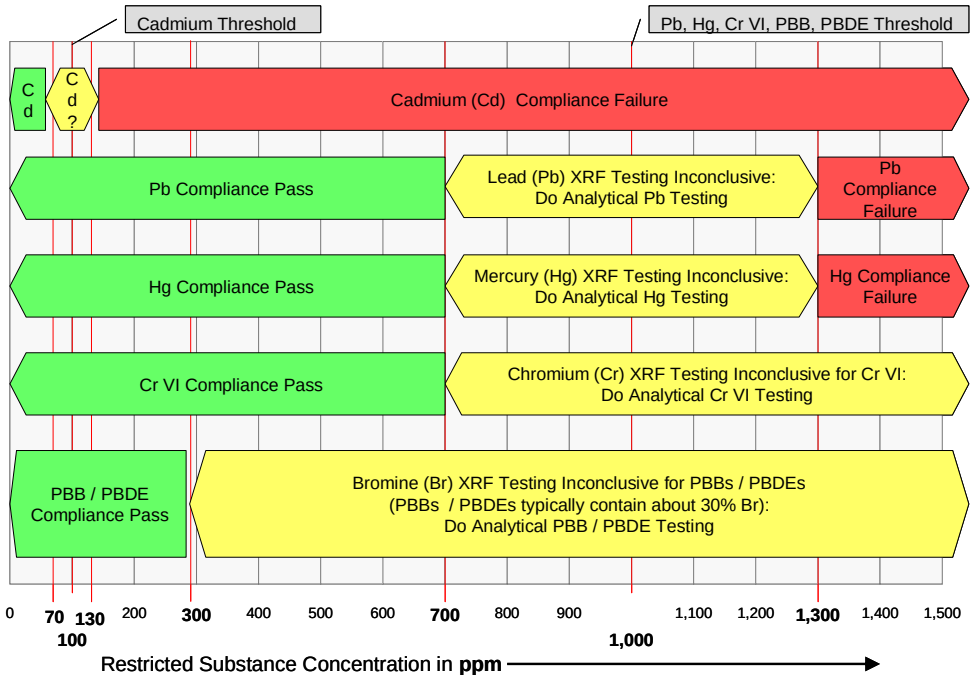


Figure 9 - Interpreting XRF analysis results and determining follow-on lab-based analysis

Analysis of Alloys and Testing for Lead in Lead-Free Solders

Analysis and identification of metal alloys, such as stainless, precious metals and copper alloys, with a portable XRF analyzer is a standard application. More important from the point of view of the RoHS compliance is testing solder alloys for the absence of lead whose presence is allowed in concentrations less than 0.1% (1000 ppm). Table 6 illustrates the precision of analysis for a SAC-305 lead-free solder. A sample of this alloy was measured ten times for 60 seconds each under the same conditions and results summarized. As can be seen, the precision of the measurement for lead, expressed as the standard deviation of the series of ten results, is equal to 0.006%, implying a Limit of Detection of about 150 ppm. This is sufficient for quantitative assaying of lead in a tin matrix down to about 300 to 400 ppm lead.

Table 8 - Precision data for constituents of Pb-free solder alloy

Measurement	%Sn	%Ag	%Cu	%Pb
Average	96.10	3.19	0.47	0.05
Std. Dev.	0.114	0.013	0.017	0.006

Table 7 shows the accuracy obtainable with the portable XRF analyzer for lead in tin solder. In this case, two certified, lead-free, tin-based reference materials were measured for 60 seconds each. As the table shows, the analyzer can accurately detect lead in a tin matrix down to 300-400 ppm.

Table 9 - Accuracy of Pb testing in Pb-free tin-based solders

Sample	Measured Pb Concentration (ppm)	Certified Pb Concentration (ppm)	Accuracy (ppm)
MBH 74X HA	300	250	50
MBH 74X HB	600	510	90

Hand-Held XRF Strengths and Relative Costs

Hand-held XRF provides the electronics industry with a solution to the problem of screening of plastics and metals for compliance with pending regulations. They are simple to use, robust, fast, and less expensive than either their laboratory counterparts or other types of analytical instrumentation. They don't require any consumables and their maintenance costs are minimal.

The portability aspect of the hand-held devices is important. Bringing the *laboratory* to the incoming inspection area results in improvements on many fronts. First, the cost of testing with a portable device is smaller than multi-elemental

laboratory analysis of a destructively extracted sample. Secondly, on-site XRF analysis yields results in real-time which means more parts can be tested more extensively. The increased level of testing translates into better compliance.

Putting It All Together

A robust due diligence-based strategy for RoHS compliance should include the following key elements and may look like the following illustration:

- Compliance Management System
- Sourcing and maintaining compliance, material declarations and related information
- Sourcing and tracking environmental regulations around the world
- Physical verification using lab-based analytical processes
- XRF for screening of incoming parts and materials
- IECQ process certification

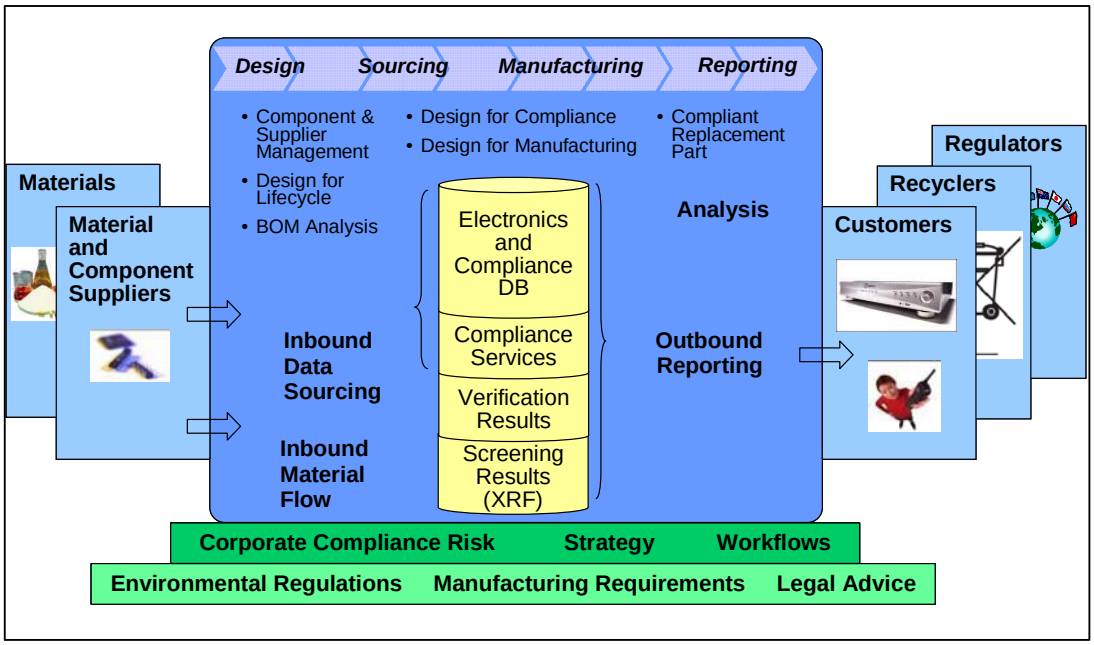


Figure 10 - Key Elements for Due Diligence-Based RoHS Compliance

Conclusion

Manufacturers need to address environmental regulations that continue to evolve. By focusing on the use models that need to be enabled, companies can determine the content requirements to drive them. Once the content requirements are known, companies can formulate strategies using a mix of material composition and compliance sourcing, lab-based physical verification and XRF-based screening analysis. The strategy can then be translated into a cohesive process and then IECQ-certified. By putting these strategies effectively to work, companies can gain confidence in their compliance.

Legal notice

Confident in Your Environmental Compliance

With contributions from:

IPCWorks 2006

Dallas, TX

Agenda

- Industry Trends
- Due Diligence
- Material Composition Collection
- Lab-Based Analysis
- IECQ Certification
- XRF Screening
- Putting It All Together

Regulations trigger market events

… Wal-Mart Stores, Inc. has partnered with Toshiba America Information Systems, Inc., to develop the first RoHS (Restriction on Hazardous Substance) laptop available in the U.S. retail channel…

Feb. 22, 2006
PRNewswire-FirstCall

Law and regulation can be market enhancing – when all regulated entities face the same obligations under the law, the smartest corporations will find a way to comply with imagination and less cost.

THE WALL STREET JOURNAL.

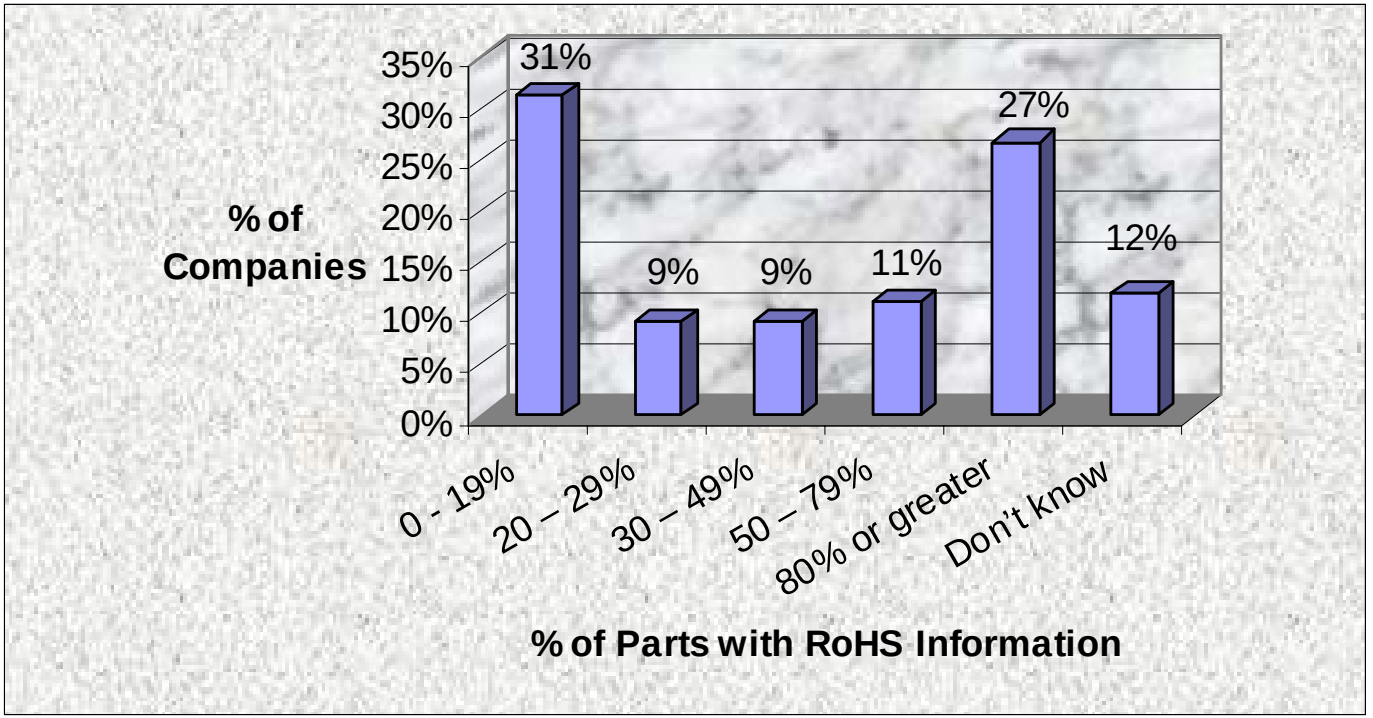
Ben Heineman, Jr
SVP for law and public affairs at GE

Palm has been forced to stop shipping its Treo 650 smartphone in Europe, because it violates new environmental laws introduced at the start of this month. July 06, 2006 ZDNet UK

Q4 2001: Cadmium found in Sony Playstation® cables by Dutch port authorities under the Dutch environmental regulations. Lost opportunity associated with this estimated at $160M.

Industry Trends
(August 2006 Webinar)

For what percent of your parts have you obtained RoHS compliance and restricted substance concentration and weight information?



Observations:

- Only about a about a quarter of companies have RoHS information on 80% or more of their parts
- Less than half of the companies have RoHS information on at least 50% of their parts

Agenda

- Industry Trends
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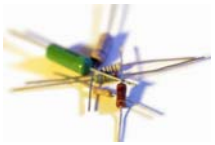
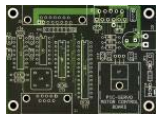
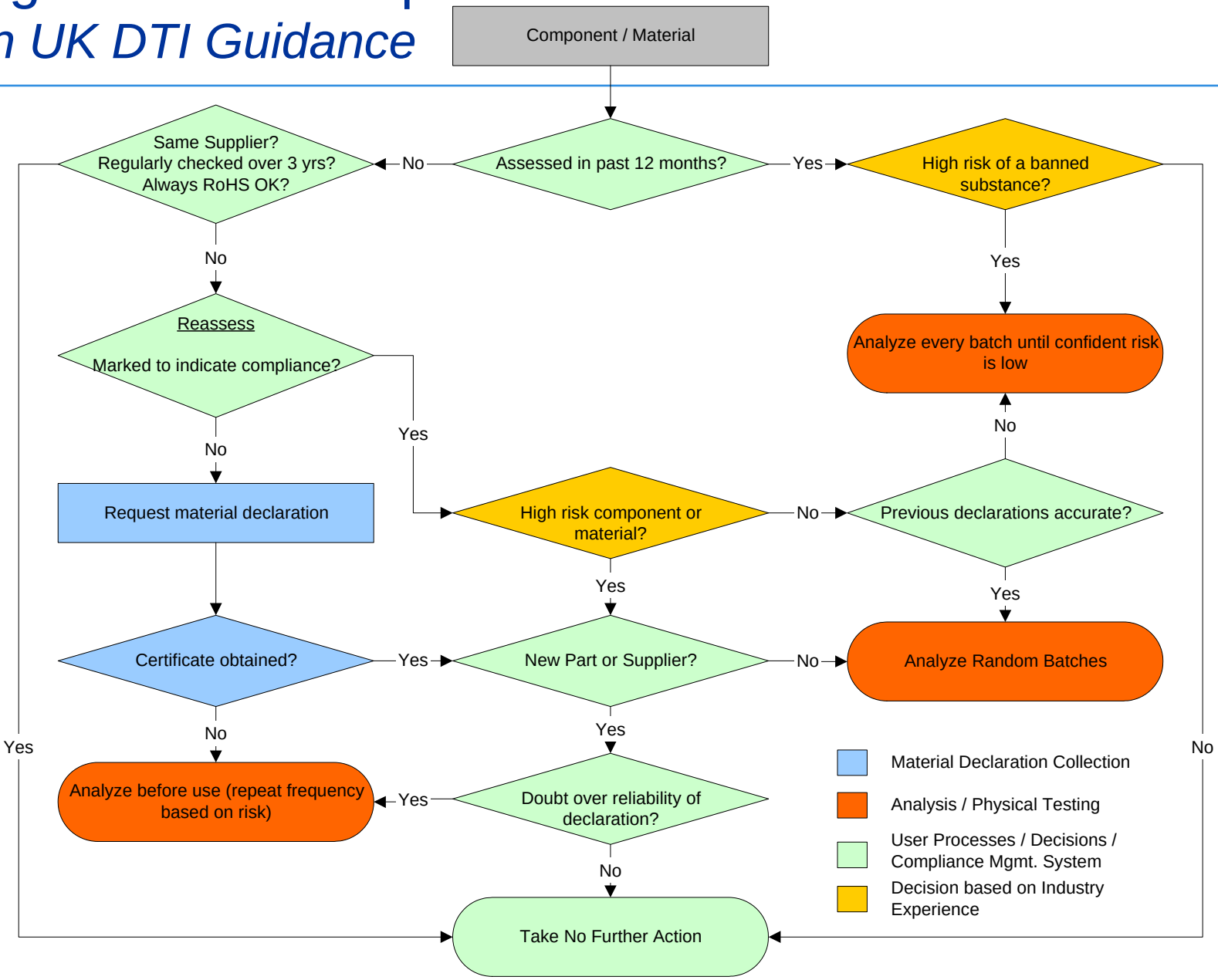
Due Diligence Roadmap

Based on UK DTI Guidance

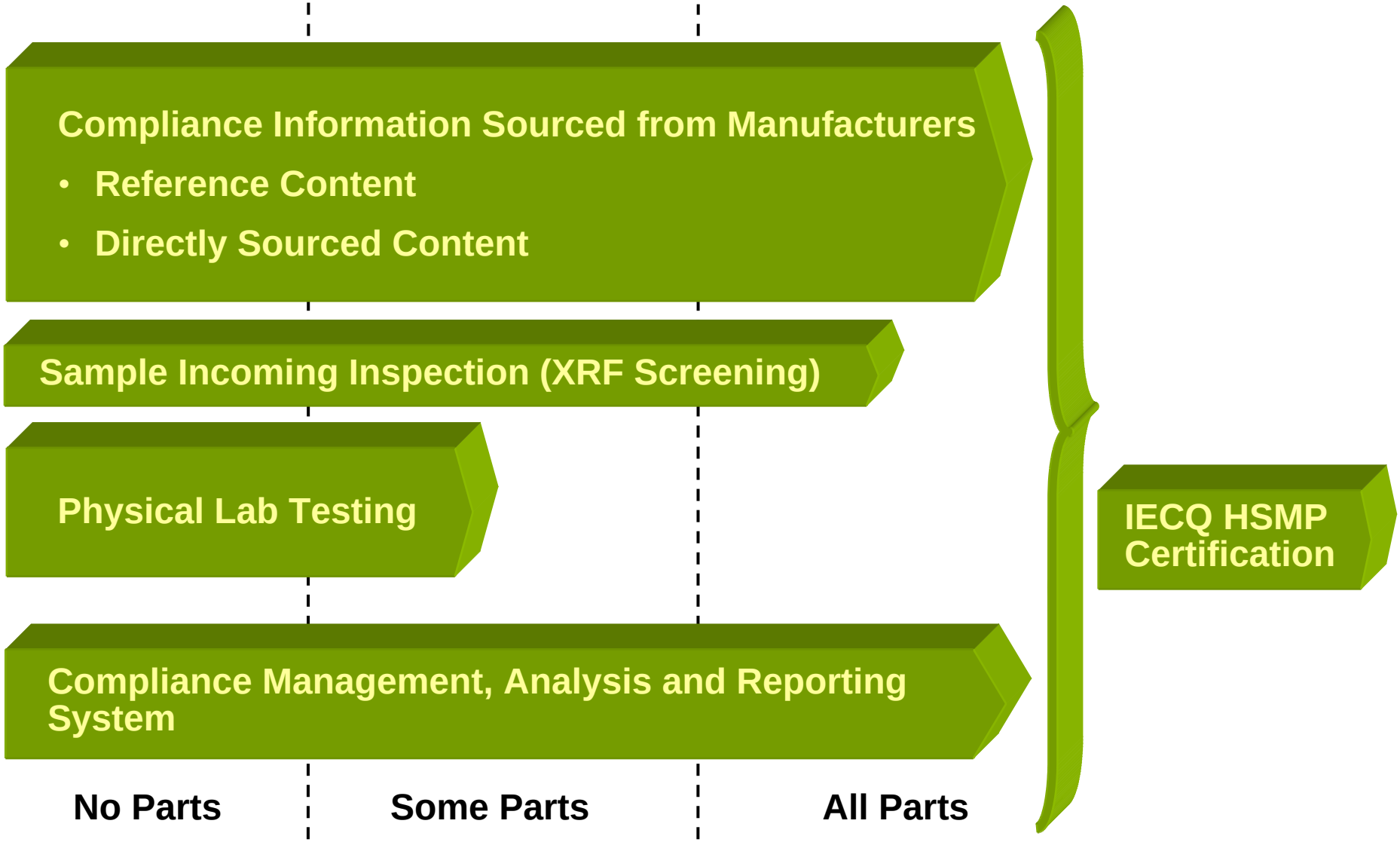






Complete Compliance Solution

Reference Content, Data Services, Verification, Screening



Agenda

- Industry Trends
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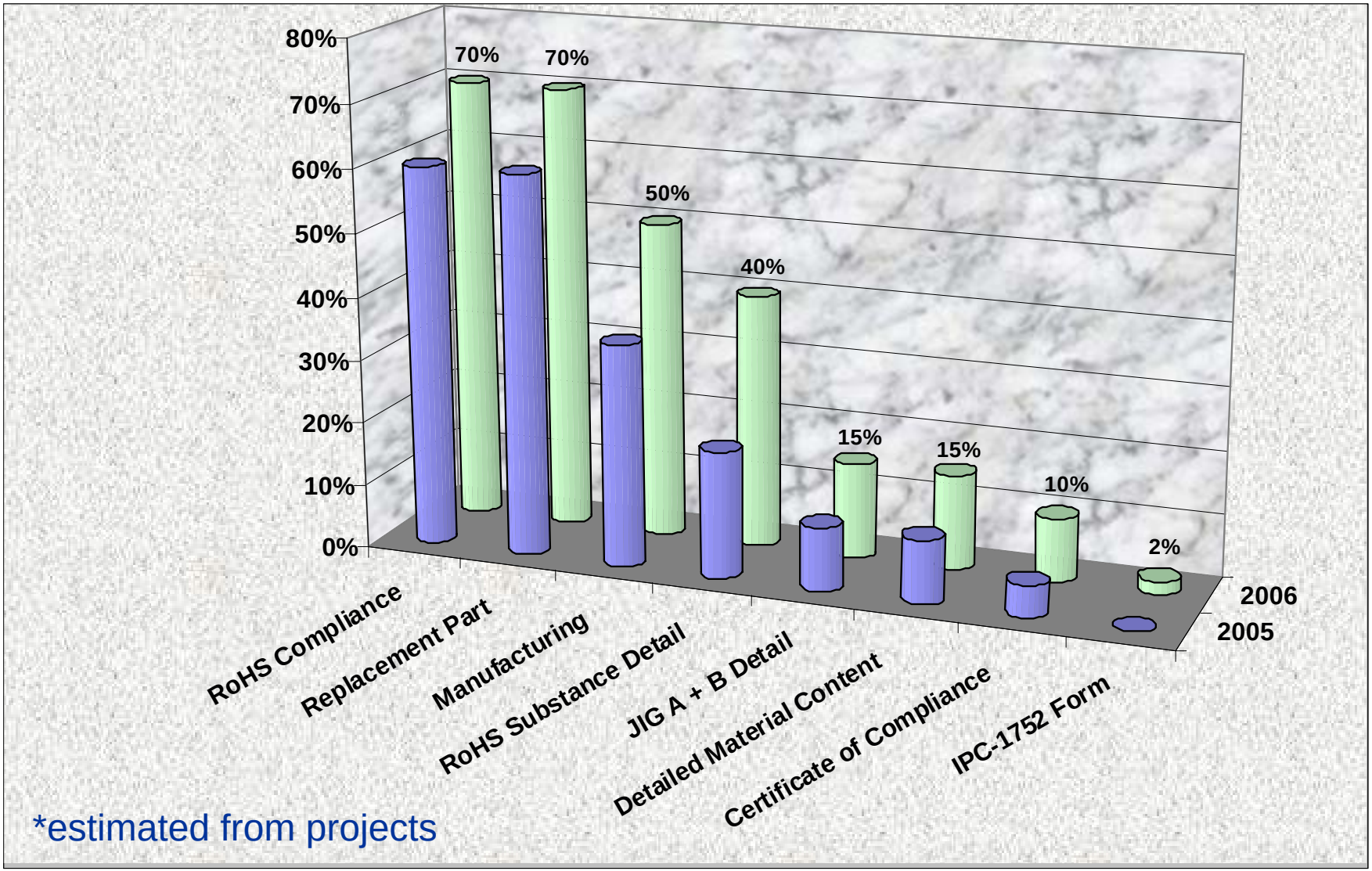
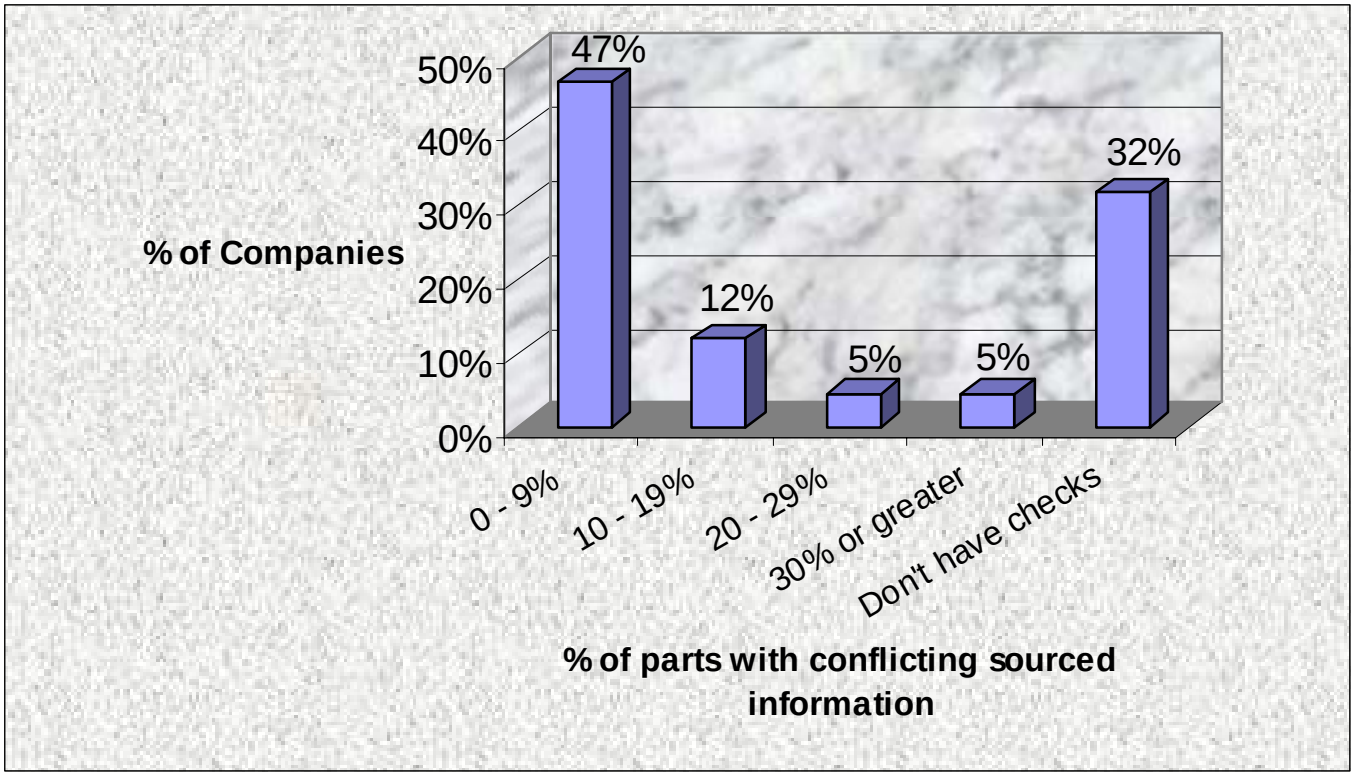
Compliance Trends from Projects

Information found on the web for Electronic Parts



Industry Trends
(August 2006 Webinar)

For parts for which you've sourced compliance information, what percentage has conflicting information*?



Observations:

- 32% of companies don't have checks
- About 22% of companies find inconsistencies with at least 10% of their parts

Agenda

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Lab-based testing

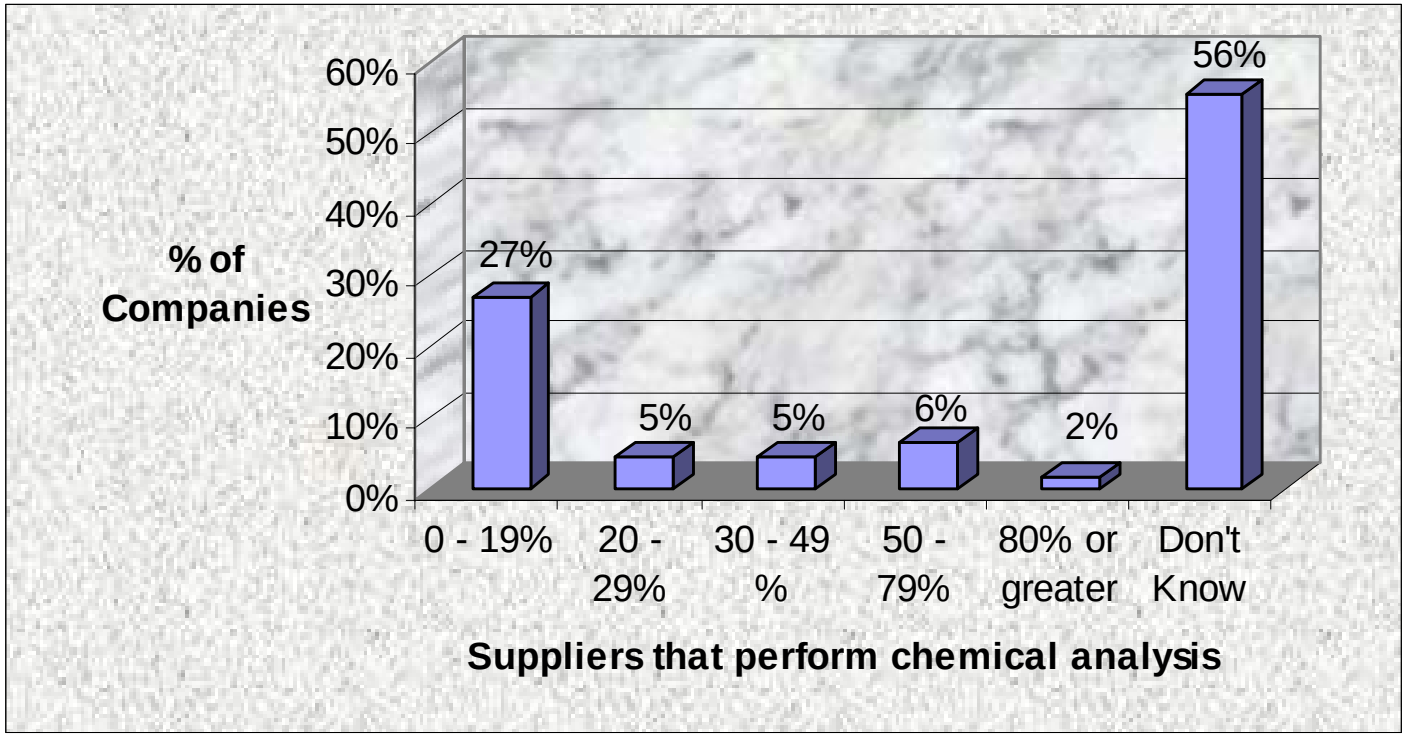
- Sample preparation and chemical analysis to determine material composition and substance concentration levels with high precision
- Verification is an important and necessary part of due diligence
- Works in complimentary fashion with material declaration collection and XRF screening
- Testing Standards
  - Evolving IEC TC111 WG3, Std expected by end of 2006
  - Deconstruction Standard not finished

Compiling high-risk parts and assessing testing

Assembly Components								
				Potential Content Risk Levels				
No.	Component	Color	Composition	Pb	Hg	Cd	Cr^{+6}	PBB/ PBDE
3	Mounting Screw	Silver	Metallic	Medium	Low	Medium	Medium	N/A
4	Support	Black	Polymeric	Medium	Low	Medium	Low	Medium
5	Housing	Black	Polymeric	Medium	Low	Medium	Low	Medium
8	Rotor	Silver	Steel	Medium	Low	Medium	Medium	N/A
9	Shaft	Silver	Steel	Medium	Low	Medium	Medium	N/A
10	Wires	Copper	Copper	Medium	Low	Medium	Low	N/A
11	Wire Insulation	Red	PVC	High	Low	High	Medium	Medium
12	Wire Insulation	Blue	PVC	High	Low	High	Low	Medium
14	Wire Connector	White	Polymeric	Medium	Low	Medium	Low	Medium
15	Printed Circuit Board	Green	Polymeric, Metal, Ceramic	Medium	Medium	Medium	Medium	Medium
16	Solder	Silver	Solder	Medium	Low	Medium	Low	N/A

Industry Trends
(August 2006 Webinar)

What percent of your suppliers perform chemical analysis to determine RoHS compliance?



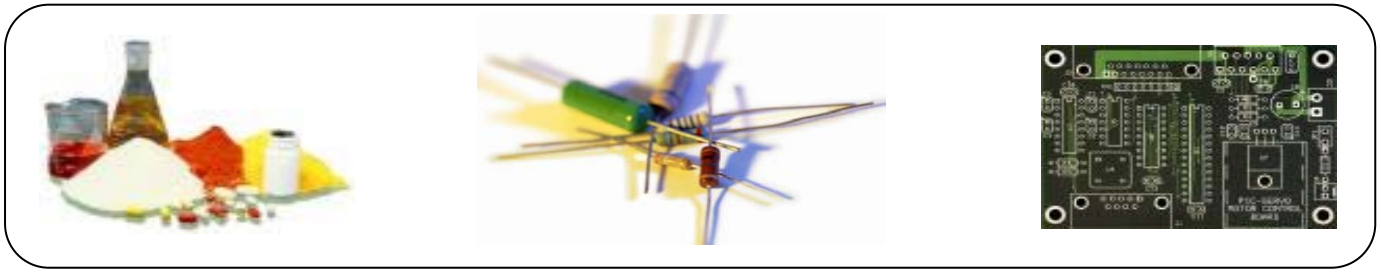
Observations:

- Most companies don't know if their suppliers perform chemical analysis
- Only 8% believe at least 50% of their suppliers perform chemical analysis

RoHS Product Certification

Material and Product Certification

- For parts with few homogeneous materials
- Testing of each homogeneous material for restricted substances
- Periodic surveillance of manufacturer operations
- Best for raw materials, electronic components, mechanical fasteners, etc.



Agenda

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IEC Quality Assessment System for Electronic Components—Hazardous Substance Process Mgmt.

IEC
International Electrotechnical Commission

Develops standards for electrical and electronic technologies

IECQ
IEC Quality Assessment System for Electronic Components

Certification Program

Certificate Number

Issued: June 02, 2006
Revision: N/A
Expiration: June 01, 2009

IECQ Certificate of Hazardous Substance Process Management (HSPM)

applicable to the European Directive 2002/95/EC ("RoHS") requirements and relevant customer requirements

The Supervising Inspectorate (Underwriters Laboratories Inc.) and the United States National Authorized Institution (ECCB) Certifies that

Taiwan Semiconductor Manufacturing Company, Ltd.
No. 6, Creation Rd. 2,
Science-Based Industrial Park,
Hsin-Chu, Taiwan 300-77, R.O.C.

Has developed and implemented Hazardous Substances Process Management procedures and related processes in compliance with the applicable requirements for HSPM organization approval which is in accordance with the Basic Rules IECQ-01 and Rules of Procedure QC 001002-5 "IECQ Hazardous Substances Process Management" of the IEC Quality Assessment System for Electronic Components (IECQ), and with respect to specification QC 080000 IECQ HSPM

For the following scope of activity

The development of IC foundry wafer fabrication design rules, IP/libraries and associated wafer/IC manufacturing.

Approved by American National Authorized Institute

Issued by Certification Authorities:

QC 080000 - HSPM
www.ul.com/ecs

Electronic Component Certification Board

UL File No. A15453 **Underwriters Laboratories Inc.**

The validity of this certificate is maintained through on-going surveillance inspections.
Note: This certificate is valid only in conjunction with the approval document(s). This approval and this certificate may be suspended or withdrawn in accordance with the Rules of Procedure of the IECQ. This certificate remains the property of Underwriters laboratories Inc. and the body which granted it.

HSPM (QC 080000)
Hazardous Substance Process Management Certification

- Complementary to ISO 9001:2000
- Certifies corporate processes to identify, control, quantify and report use of hazardous substances in products
- Provides credible third party assurance to regulators showing due diligence
- Authorized Supervising Inspectorates certify processes

Agenda

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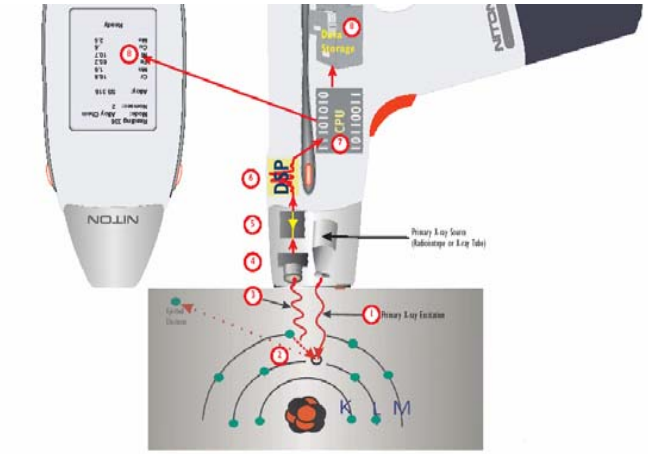
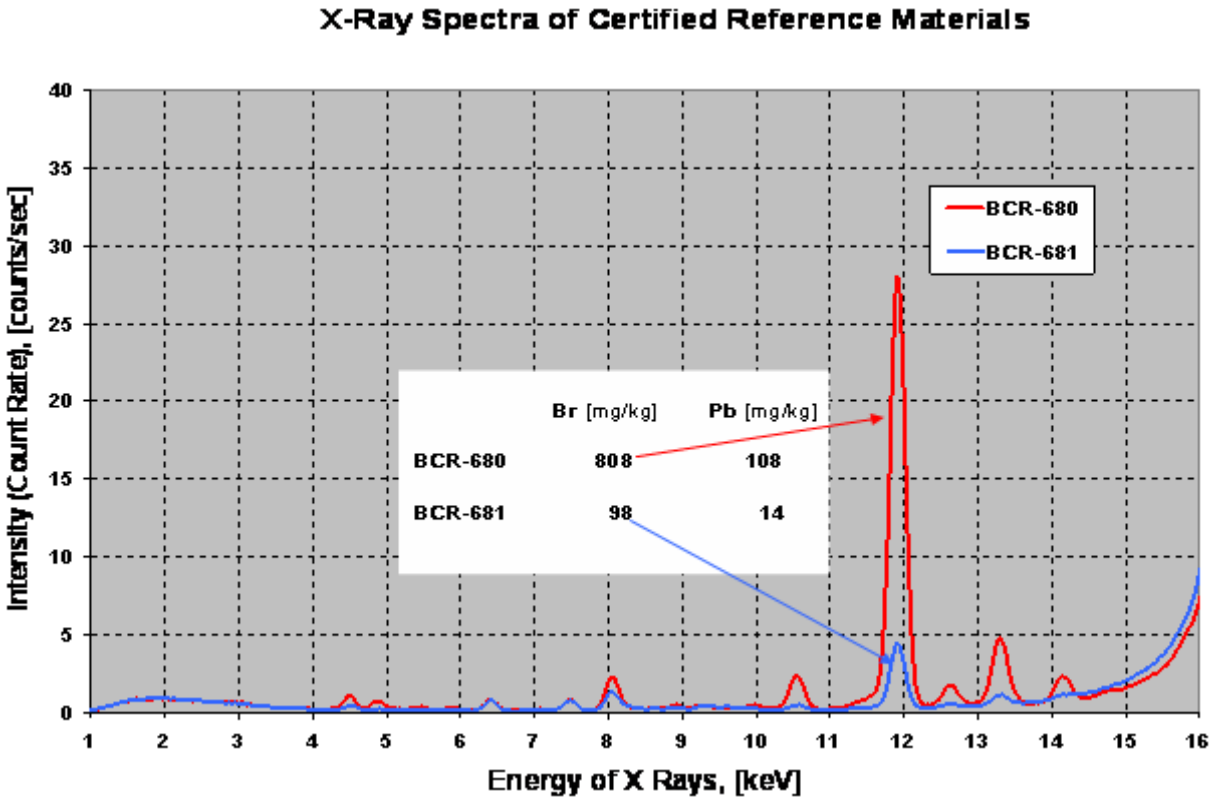
XRF

- Non-destructive testing
- Suitable for incoming inspection
- Tests for multiple banned substances simultaneously
- Low-cost, quick, onsite





XRF for RoHS Screening

...*sorting the test results*

Declared Compliant Part or Material

Pass

- ***OK***

Inconclusive

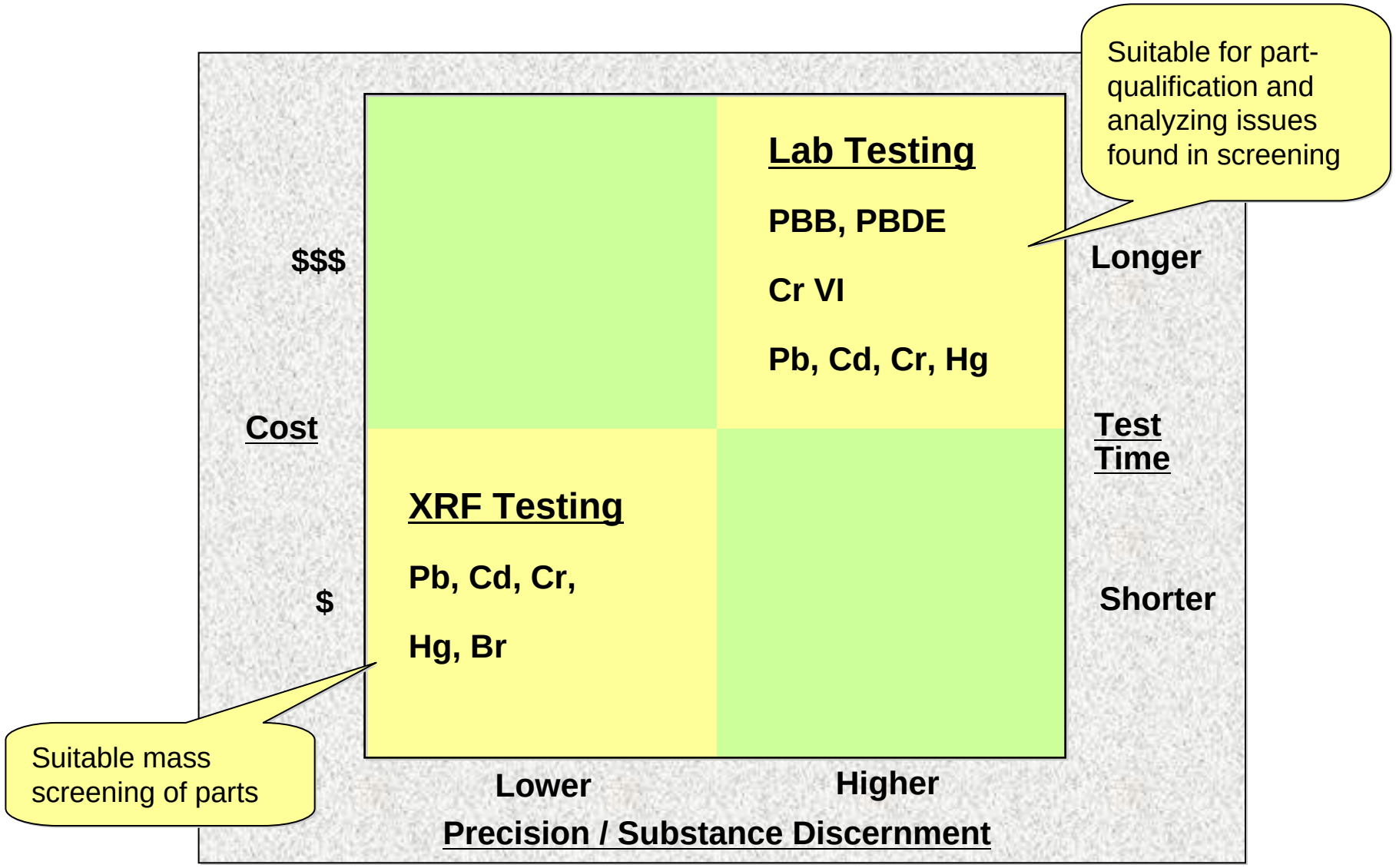
- ***Do Analytic Testing***

Fail

- ***Follow-up with supplier on inconsistency***

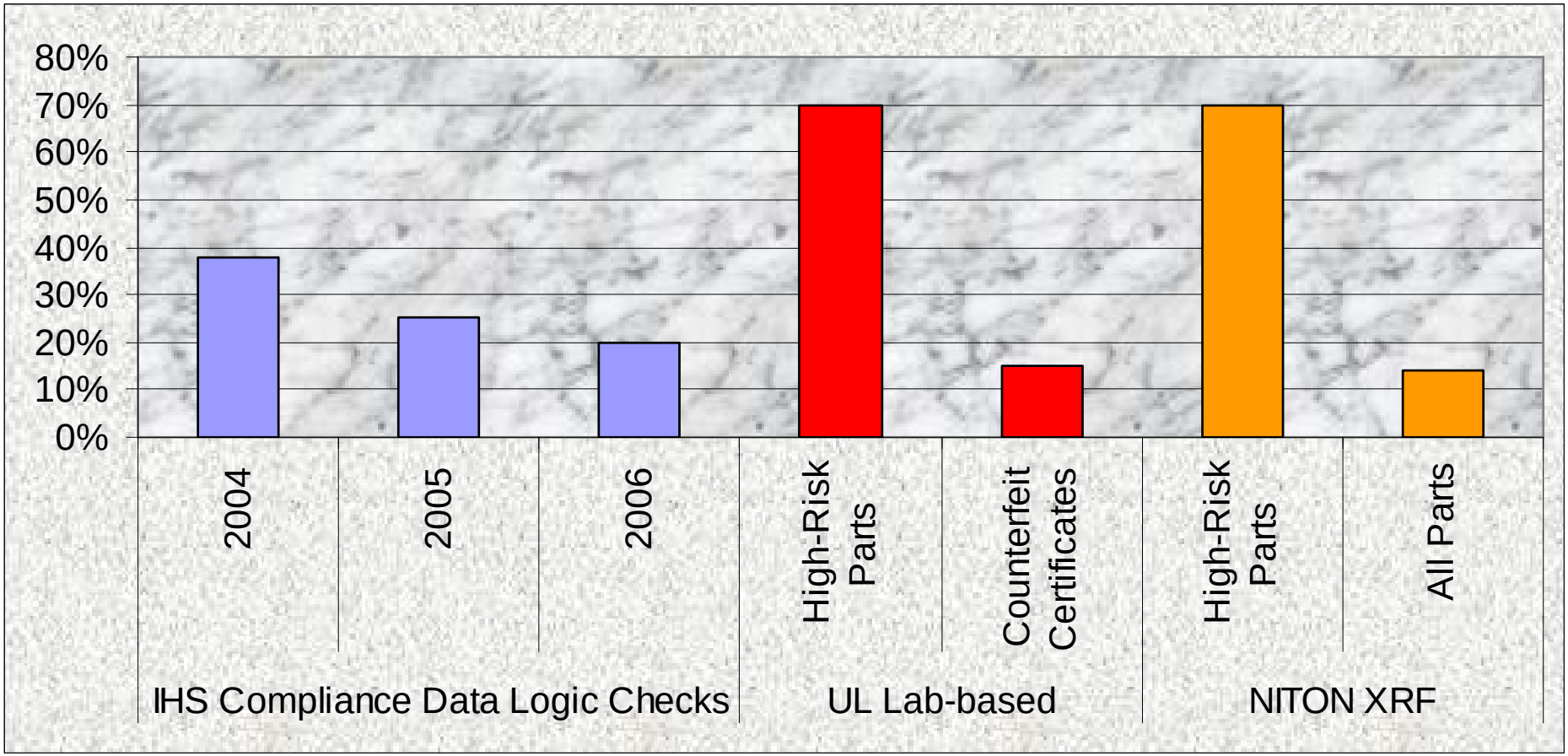
Cost-Accuracy Trade-Offs

Complimentary Nature of Lab-based and XRF Analysis



Compliance Trends from Projects

Compliance Issues Detected: Content, Analysis, Screening



- average and/or typical project numbers

Agenda

- Industry Trends
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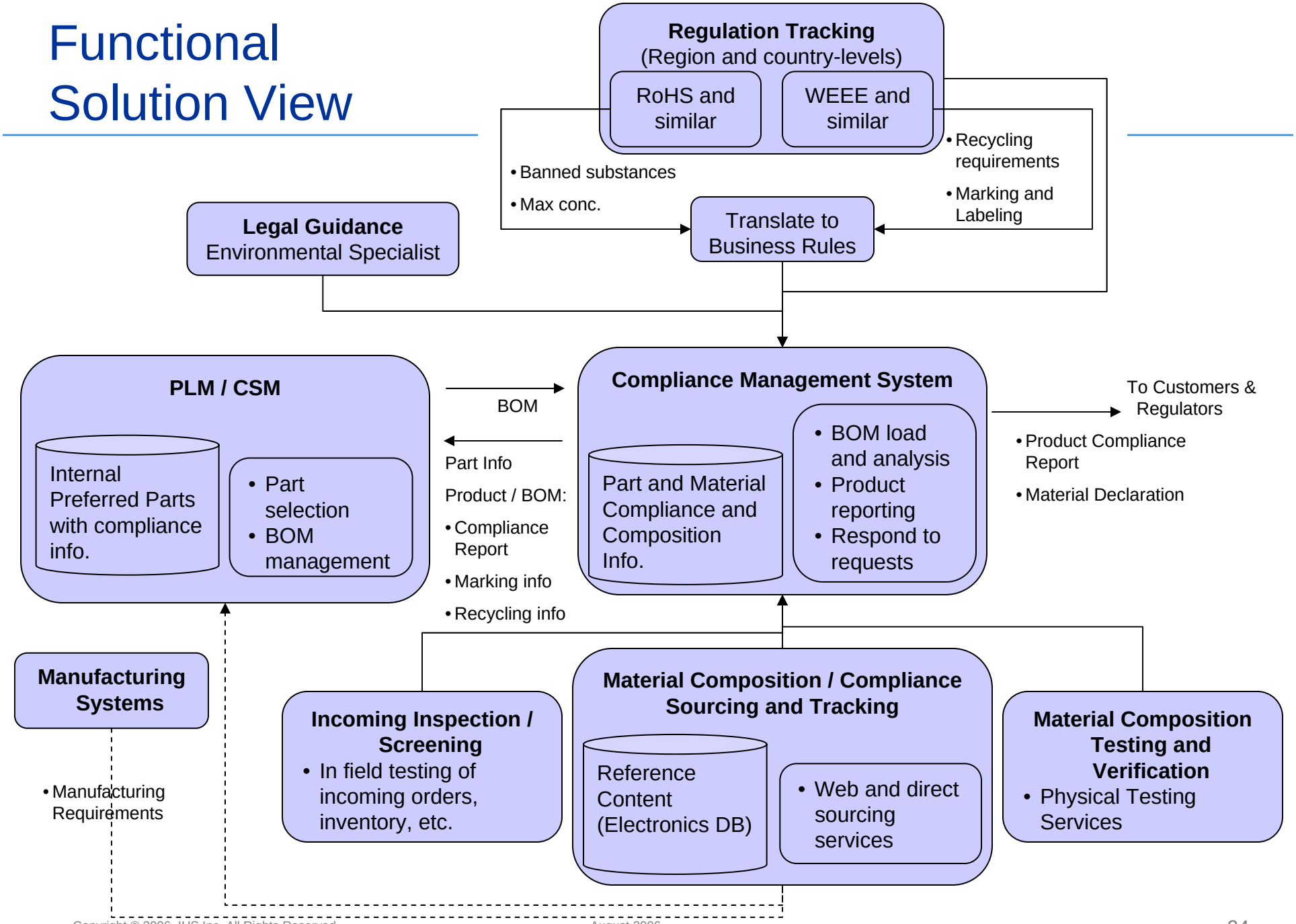
Functional Solution View



Confident in Your Environmental Compliance

With contributions from:

IPCWorks 2006

Dallas, TX