



An Assessment of Heavy Metals in Packaging: 2009 Update

Final Report

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The Toxics in Packaging Clearinghouse

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An equal opportunity provider and employer.

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The contribution of all TPCCH members was critical to the success of the project. These members include:

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An Assessment of Heavy Metals in Packaging: 2009 Update

Executive Summary

Nineteen U.S. states have toxics in packaging laws that prohibit the sale or distribution of packaging containing intentionally added cadmium, lead, mercury, and hexavalent chromium, and set limits on the incidental concentration of these materials in packaging. The purpose of these laws is to prevent the use of toxic heavy metals in packaging materials that enter landfills, waste incinerators, recycling streams, and ultimately, the environment.

Most state toxics in packaging laws were passed in the early 1990s, with the exception of California, where the law was adopted in 2003. Anecdotal evidence suggested sweeping changes within the regulated industries after the passage of these laws to eliminate the use of restricted heavy metals in packaging applications and to achieve regulatory compliance. Since laboratory testing was prohibitively expensive, states' ability to broadly test this assumption went largely un-validated until 2006, when the Toxics in Packaging Clearinghouse (TPCH) initiated its first screening project using x-ray fluorescent (XRF) screening technology. XRF offered a rapid and inexpensive option for screening large volumes of packaging for the presence of heavy metals.

In 2007, TPCH released the first comprehensive report on heavy metals in packaging, based on XRF screening, with some unexpected results. Heavy metals restricted by state toxics in packaging laws, particularly lead and cadmium, were frequently found in some types of packaging and packaging components, particularly imports.

This 2009 Update documents the continued investigation by TPCH of heavy metals in packaging, using XRF analysis. In 2008, TPCH screened an additional 409 packages to detect trends in compliance with state toxics in packaging laws and identify areas where TPCH should focus, or continue to focus, its outreach efforts. TPCH used the screening results to notify brand owners¹ of potentially non-compliant packages about toxics in packaging requirements, and to bring non-compliant packages into compliance.

A. Packaging Screening Results

Fifty-eight packaging samples, or 14.2 percent of all samples exceeded the 100 ppm screening threshold for one or more of the restricted heavy metals, and therefore, are likely not in compliance with state laws.² Packaging components that failed the screening test (>100 ppm of one or more of the 4 restricted metals) generally fell into one of three groups: imported flexible PVC, inks and colorants, and solder used in electronic circuitry. XRF screening did not detect any of the restricted heavy metals in concentrations greater than 100 ppm in the paper-based

¹ For the purpose of this report, a "brand owner" is the company whose name is identified on the package as the product manufacturer, importer, or distributor. In some cases, the package or packaged product was made for, or distributed by a retailer, making them the brand owner or responsible company that received TPCH notifications.

² These results include packages that failed the screening test due to total chromium. XRF measures total chromium, not hexavalent chromium. Laboratory testing may be needed to determine if the chromium is hexavalent chromium.

packaging components tested. Similarly, all semi-rigid PVC packaging components (e.g., blister packs, clamshells, boxes) screened passed the screening tests, in contrast to flexible PVC.

Cadmium was the most frequently detected of the four regulated metals, followed by lead. All packaging samples failing for cadmium content were flexible PVC, and over 90 percent of these were imported. Flexible PVC, a “heavy-duty” plastic material, is frequently used to package home furnishings, pet supplies, cosmetics, and inexpensive toys. Metals, including cadmium and lead compounds, can be used as heat stabilizers in PVC resin to control degradation during processing and use, according to the Vinyl Institute.³ The home furnishings sector (e.g., packaging for sheets, shower curtains, tablecloths) had the highest percentage (19 of 44 samples or 43%) of all packages tested that failed the screening test; all were flexible PVC.

Lead was detected in one-third of the failed packaging samples. The types of packaging materials that contained lead in this study were more diverse than those containing cadmium. Lead was found in inks and colorants used in shopping bags, flexible PVC, and solder. The concentration of lead ranged from 122 ppm to 150,388 ppm. The lead concentrations in PVC were on the lower end, generally falling below the median concentration (450 ppm), while lead in inks and colorants was more often detected at concentrations above 1,500 ppm. Lead solder used in one packaging application was the outlier at over 150,000 ppm.

Comparing packaging screening results from the 2006 project to the 2008 project shows a decrease in the number of packaging components failing the screening tests in two packaging categories: flexible PVC samples and inks and colorants. The exact reason for the decline is not known, but anecdotal evidence suggests that the outreach efforts of the Clearinghouse undertaken as part of the 2006 project, and subsequent state enforcement efforts, contributed to the decline.

B. Company Outreach and Results

TPCH notified 33 companies that their packaging failed the XRF screening for one or more restricted heavy metals. Thirty-nine percent of these companies confirmed that their packages were not in compliance with state laws, and discontinued their sale and distribution. As a direct result of TPCH notification, companies recalled packages and stopped shipments into the U.S. They also took steps to reduce the use of heavy metals, particularly lead and cadmium, in future packaging supplies. Companies changed suppliers or packaging materials and implemented new quality assurance practices to detect the presence of the restricted metals in incoming packaging materials, which will allow for earlier and less costly corrective actions. Finally, these companies embarked on new initiatives to educate and better manage their supply chains.

Sixteen companies (48% of companies notified) submitted Certificates of Compliance with supporting documentation to TPCH claiming that their packages were in compliance with state laws. Despite the claims of compliance, some of these companies chose to implement new or additional quality assurance practices related to toxics in packaging and reinforce toxics in packaging policies with suppliers.

³ The Vinyl Institute, “Use of Metal Process Additives in the U.S. Vinyl Processing Industry,” October 2007.

TPCH attributes this discrepancy between TPCH XRF screening results and company compliance claims to several possible scenarios. First, testing laboratories may still be using inappropriate sample preparation methods for measuring total concentration of heavy metals, resulting in false “positives.” Second, anecdotal evidence suggests that suppliers, particularly overseas suppliers, may be submitting false certifications and test results. Third, the packaging material tested by the company might be in compliance, but it is a different material than the sample screened by TPCH. Finally, it is possible, but not very likely, that the TPCH screening results are incorrect. This final explanation is least plausible, given that more than a third of the companies notified concurred with TPCH test results for packages with similar materials and heavy metal concentrations as the ones in which companies refuted TPCH screening results. Further, many TPCH XRF results were confirmed by EPA SW846 Method 3052 analyses.

TPCH and member states also questioned the continued reliance on overseas supplier assurances that packaging is in compliance with state laws, and the lack of any procedures to verify or monitor compliance, in light of the number of scandals in Asia around tainted products such as lead paint in children’s toys.

The 2006 TPCH screening project found a similar discrepancy between TPCH screening results indicating non-compliant packaging and company claims. However, the 2008 compliance screening results were corroborated by more companies than in 2006 (39% vs. 15%) and had a greater impact on the type and extent of actions taken by companies.

TPCH and its member states emphasized throughout the screening project and in its communications with regulated entities the importance of sample preparation, particularly the need to fully digest the sample as a requirement for an accurate total metals analysis. TPCH consistently requested the use of EPA SW-846 Method 3052 and microwave assisted acid digestion for hard to dissolve polymer substrates. Throughout the screening project, TPCH heard objections to the use of Method 3052, with laboratories arguing that Method 3052 required the use of hydrofluoric acid, an extremely hazardous reagent that they were unwilling to use in their laboratories. However, this argument was unfounded, since Method 3052 only requires the use of hydrofluoric acid when digesting samples containing silica. Hydrofluoric acid is **not** required for effective digestion of typical plastic/PVC type package components. TPCH will continue to promote the use of appropriate sample preparation methods that yield complete dissolution, including EPA SW-846 Method 3052 and microwave assisted acid digestion among regulated entities and commercial testing laboratories. This methodology should become more widely accepted and recognized, since the Consumer Product Safety Commission published a similar test method in February 2009 for determining total lead in plastics in children’s products.⁴

C. Conclusions

The results indicate progress in reducing the toxicity of the packaging waste stream and changing industry practices, which will result in long term environmental benefits. Many of the companies contacted about potentially non-compliant packages were nationally recognized brand

⁴ [Test Method: CPSC-CH-E1002-08](http://www.cpsc.gov/ABOUT/Cpsia/CPSC-CH-E1002-08.pdf), Standard Operating Procedure for Determining Total Lead (Pb) in Non-Metal Children’s Products, February 1, 2009, available at <http://www.cpsc.gov/ABOUT/Cpsia/CPSC-CH-E1002-08.pdf>.

owners with a tremendous influence on the supply stream. For example, just the companies that acknowledged non-compliant packages and implemented corrective actions following TPCCH notification have annual sales over \$450 billion. The initiatives of these companies to eliminate heavy metals from their packages and implement new quality assurance procedures had and continue to have a ripple effect throughout the packaging supply chain.

The impact on the supply chain caused by TPCCH notification letters sent to just 33 companies, and the ensuing communications, was, and continues to be, significant. However, more work lies ahead. TPCCH will continue its efforts to reach out to multiple constituents within the packaging supply chain and different product sectors, particularly those identified in this screening project as having a higher likelihood of non-compliance, to educate them about state toxics in packaging requirements. TPCCH and its member states also expect to continue monitoring packaging for compliance with state laws, since XRF screening results have proven to be an extremely effective tool for communicating with regulated entities and sparking change. Individually, or in cooperation with each other, member states may also pursue compliance through enforcement actions.

An Assessment of Heavy Metals in Packaging: 2009 Update

I. Introduction

In 2007, the Toxics in Packaging Clearinghouse (TPCH) released its first report (“[2007 Report](#)”) on the presence of heavy metals in packaging on behalf of member states, all of which have toxics in packaging laws. The report, based on packaging screening in 2006, revealed that restricted heavy metals, particularly lead and cadmium, were frequently found in some types of packaging components. Since then, educating the regulated community has been a very high priority of TPCH and its member states. TPCH developed [several new resources](#) for the packaging supply chain to help guide the regulated community towards and maintain compliance with state toxics in packaging requirements. In [Quality Assurance Considerations for Toxics in Packaging](#), TPCH outlines key steps to ensure the quality of packaging supplies, distilled from its years of experience with screening packaging and working with the regulated community.

This current report documents the continued investigation by TPCH of heavy metals in packaging, using x-ray fluorescent (XRF) analysis. In 2008, TPCH screened an additional 409 packages to detect trends in compliance with state toxics in packaging laws and identify areas where TPCH should focus, or continue to focus, its outreach efforts. These screening results are reported here. TPCH used the screening results to notify brand owners of potentially non-compliant packages about toxics in packaging requirements, and to bring non-compliant companies into compliance, an outreach strategy that proved successful in the first screening project. This report documents the actions taken by companies to address non-compliant packages, thereby reducing the presence of toxic heavy metals in packaging.

A. Background on Toxics in Packaging Legislation

Nineteen states have toxics in packaging laws based on the Model Toxics in Packaging Legislation.⁵ (A list of states that adopted the Model Legislation is provided in Box 1.) State toxics in packaging laws prohibit the intentional use of *any amount* of lead, cadmium, mercury, and hexavalent chromium in packaging or individual packaging components, such as inks, adhesives, or labels. If the regulated metals are unintentionally present, for example, as a contaminant in raw material feedstocks, the total concentration is limited to less than 100 ppm for the sum of all four metals in any package or individual packaging component sold within these states. Limited exemptions are available for recycled-content, reusable containers, and packages regulated by other federal and state laws.

⁵ The Coalition of Northeastern Governors (CONEG) Source Reduction Task Force adopted the Model Toxics in Packaging Legislation (“Model Legislation”) and created the Toxics in Packaging Clearinghouse (TPCH) to ease the administrative burden for states and regulated industry. TPCH continues to manage the Model Legislation, but is no longer affiliated with CONEG. The Northeast Recycling Council, Inc. (NERC) now administers TPCH.

Box 1

States with Toxics in Packaging Laws

* Indicates TPCCH Member State

* California	* New Hampshire
* Connecticut	* New Jersey
Florida	* New York
Georgia	Pennsylvania
* Illinois	* Rhode Island
* Iowa	Vermont
Maine	Virginia
Maryland	* Washington
* Minnesota	Wisconsin
Missouri	

These requirements apply to all packaging and packaging components offered for sale or for promotional purposes by the manufacturer and distributor (including importers) in states with toxics in packaging legislation. The state laws further require self-certification by companies, and require companies to produce a Certificate of Compliance upon request. Most TPCCH member states have included in their laws the ability to levy substantial monetary penalties for non-compliance.

The Toxics in Packaging Clearinghouse coordinates implementation of the legislation on behalf of its member states, and serves as a single point of contact for companies seeking further information, clarification of specific details,

or an exemption to toxics in packaging requirements. Manufacturers, distributors, and retailers must deal directly with states that have adopted toxics in packaging legislation but are not members of the TPCCH. For more information on toxics in packaging legislation and the Clearinghouse, visit www.toxicsinpackaging.org.

II. Methodology

The 2006 and current (“2008”) TPCCH compliance assessment projects were designed to screen packaging for compliance with the Model Legislation and state laws based on the Model Packages, mostly from the retail market, were screened for the presence of the four restricted heavy metals -- cadmium, lead, mercury, and hexavalent chromium⁶ -- using a portable x-ray fluorescence (XRF) analyzer. The XRF testing device allowed TPCCH to make a rapid determination whether a package was likely to pass or fail the toxics in packaging requirement for the total concentration of the four heavy metals.

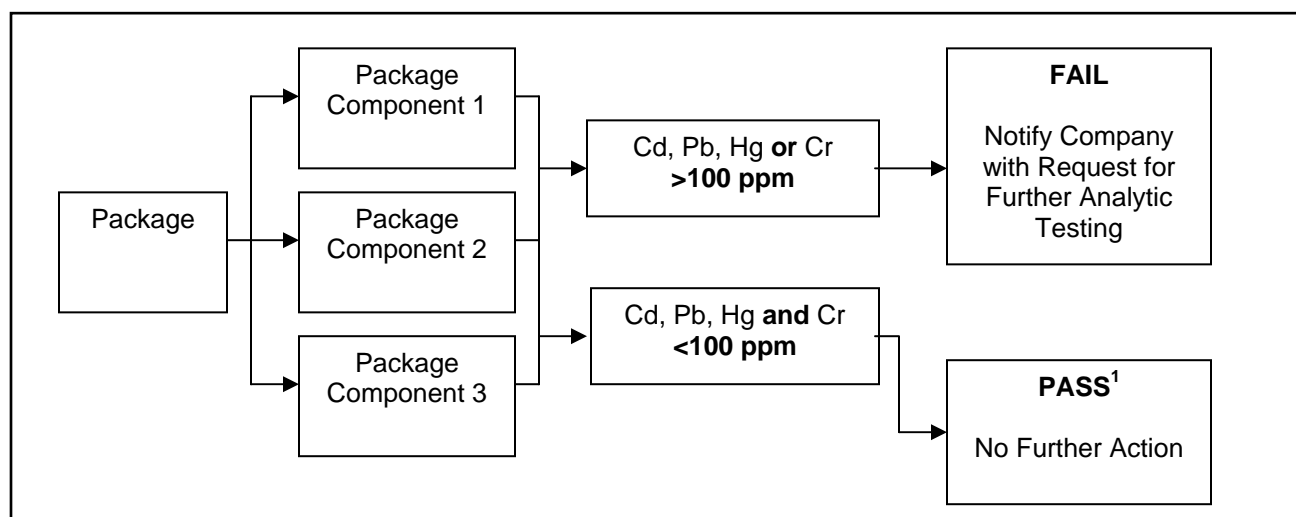
The packaging screening results were used in two ways. First, these results were used to identify patterns of potential non-compliance within specific sectors of the marketplace. For example, in the selection of some packaging samples TPCCH specifically targeted the types of packaging components identified in the first test project as having a high incidence of non-compliance with state laws, namely, imported flexible polyvinylchloride (PVC) packages; and inks and colorants used on plastic shopping and other bags. The goal in this case was to see whether the levels of non-compliance in these packaging sectors had changed since the first

⁶ XRF technology measures total chromium, not hexavalent chromium. If total chromium exceeded 100 ppm, TPCCH requested an explanation of the source and type of chromium used in the package and a Certificate of Compliance with laboratory test results documenting the concentration or absence of hexavalent chromium in the packaging.

screening project. TPCCH also selected packaging samples that were not well represented in the initial screening project in order to identify additional packaging sectors on which to focus its outreach efforts.

Second, the packaging screening results were used to initiate direct contact with brand owners of potentially non-compliant packaging. This approach was an effective outreach tool in the 2006 screening project, and was deemed to be worth repeating in this project. As depicted in Figure 1, if the concentration of one or more of the restricted metals exceeded 100 ppm in one or more packaging components, the package “failed” and the product brand owner was notified that its package failed the screening test. One hundred parts per million (100 ppm) was chosen as the trigger for notification letters in the compliance test program because this concentration level indicates potential non-compliance due to intentional introduction and/or incidental presence. The screening test protocol did not differentiate between intentional addition and incidental presence of heavy metals.

Figure 1: XRF Screening Test Protocol



¹ In this project, “pass” refers to the screening test results only, and does not indicate compliance with state laws. To be compliant with state laws, a package or packaging component must also meet the requirement for no intentional introduction of any amount of the 4 metals, in addition to the < 100 ppm requirement for incidental presence.

Manufacturers and distributors selling suspected non-compliant packaging were notified of the screening results and provided with information on the Model Toxics in Packaging Legislation and state laws based on the Model. TPCCH requested that these companies certify compliance and provide supporting analytic data, or notify the TPCCH that the package was not in compliance with state laws and discontinue the distribution and sale of the package in TPCCH member states.

The following sections describe in greater detail the packaging selection and acquisition protocols, the test procedures, and the outreach strategy.

A. Sample Selection and Acquisition

TPCH screened 409 packages representing different product sectors, packaging types (e.g., bags, boxes, and caps), and material types (aluminum, glass, paper, plastics, and steel). Packaging was selected for screening in several ways. Some packaging components were targeted based on the results of the 2006 TPCB screening project that indicated a high likelihood of potential non-compliance. Two types of packaging dominated the non-compliant packages in the 2006 screening project, and were therefore targeted for further screening: 1) flexible PVC packages used to package home furnishings, pet supplies, inexpensive toys, and cosmetics; and 2) inks and colorants on plastic shopping and mailing bags.

TPCH also sought packaging suspected of non-compliance as a result of interim screening or industry knowledge; packaged products sold or distributed by companies whose packaging failed in the 2006 screening project; and packaging materials, components or product types not previously tested or underrepresented in the initial test program. It is important to note that, unlike the initial project in 2006, it was not the intention of the current screening project to select packaging samples to represent the spectrum or proportion of packaging materials or types in the marketplace.

Table 1 summarizes the types of packages tested by product sector. TPCB member states and staff acquired packaging samples through routine business or personal purchases, or in some cases, to secure targeted packaging samples. Collection forms recorded information on the sample, its purchase, and chain of custody. All samples were delivered to TPCB (either hand delivered or by U.S. mail) for testing, where the sample was assigned a sample number. Descriptive information on each sample was recorded directly into the XRF software prior to testing.

Table 1: Packages Tested by Product Sector

Product Sector	No. of Samples	Product Sector	No. of Samples
Shopping Bags	85	Apparel	13
Grocery Items	60	Office Supplies/Stationary	12
Home Furnishings	44	Grocery In-store Service Bags ¹	10
Produce Bags	36	Art Supplies	10
Toys & Games	36	Mailing/Shipping	8
Hardware	17	Sporting Goods	7
Pet Supplies	15	Beverage	7
Cosmetics/Personal Care	15	Fast Food	3
Electrical & Electronic	15	Baby Equipment/Supplies	1
Household Items	14	Novelty	1

¹ Including self-service produce, in-store bakery, and fish market.

Each of the 409 packaging samples was separated into individual packaging components, resulting in a total of 628 packaging components screened over the course of this project. For example, a package containing curtains was separated into two or three components, depending on the package design: the plastic bag or pouch, the paperboard insert, and if present, the zipper.

In this case, even though the plastic bag might have been the reason that this package was selected for screening, breaking apart the package into its component parts broadened the types of materials subject to XRF screening. It was not, however, always possible to separate packaging components; ideally, colorants, inks, and adhesives should be tested individually. Since this project acquired finished packages (e.g., shopping bags with graphic designs) and not the raw materials, packaging components were isolated to the extent possible.

Figure 2 provides a breakdown of the major materials in the packaging components tested. Plastic and paper-based packaging dominated the samples with 62 percent and 33 percent, respectively.

Figure 2: Packaging Components Tested by Material Type

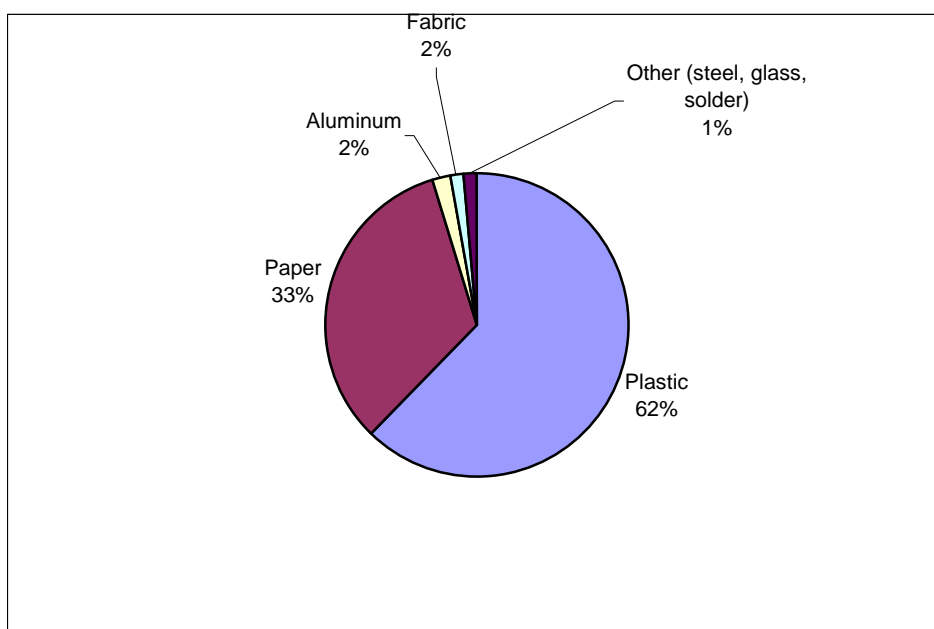
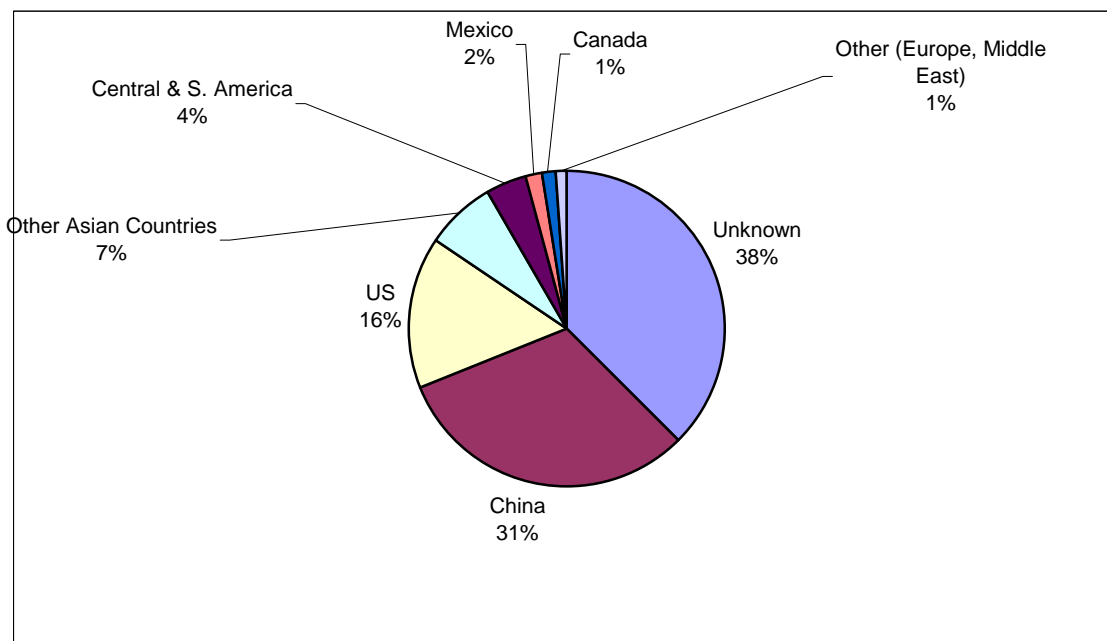


Figure 3 shows the country of origin for the packaging samples. It is assumed for the purposes of this study that the country of origin on the package applies to both the product and package, except in cases where the origin of the packaging is explicitly stated. Imports dominated the packaging samples with China and other Asian countries accounting for almost 40 percent of the packages. However, not all packaging samples were labeled with the country of origin. Thirty-eight percent of the packages were of unknown origin. Country of origin was typically found on packaged products, while some packaging types -- shopping bags, produce bags, mailing bags, and fast food packaging -- were often not labeled.

Figure 3: Packaging Samples By Country of Origin

Note: The percentage of packaging samples of “unknown” origin was high due to the number of shopping, produce, and mailing/shipping bags tested. These packaging types rarely identified country of origin.

B. Sample Preparation and Test Procedures

The test program was designed to screen packages for the presence of the four restricted metals using x-ray fluorescent analysis. Testing was performed using an Innov-X Systems Alpha Series™ instrument, which uses nondestructive energy-dispersive x-ray fluorescence technology to determine the elemental composition of samples. Although portable, all testing was performed with the analyzer docked into a stationary test stand as shown on the right. The instrument was connected by serial cable to a laptop computer that allowed remote, hands-free equipment operation.



Table 2 shows the detection limits for the four target heavy metals in two polymer matrices (PVC and non-PVC), aluminum alloys, tin based solders, and other alloys. Detection limits are a function of testing time, type of sample matrix, and the presence of interfering elements. The reported detection limits for plastics and aluminum alloys for the four restricted metals are 10 – 40 ppm, while tin-based solders and other alloys detection limits in the 200 – 250 ppm range. These detection limits are based on 120 seconds (2 minute) measurement times. The

Table 2: Limits of Detection (LOD) in ppm for a Measurement Time of 120 seconds

Element	Matrix					
	Plastic (non PVC)	PVC Plastic	Aluminum (Al) Alloy	Tin (Sn) Solder	Other Alloys (not Al or Sn)	Sand Matrix (SiO ₂)
Cd	25	25	12	250	60	25
Pb	10	20	11	200	200	13
Hg	10	20	16	NA	NA	14
Cr	25	40	40	NA	200	25

Source: Innov-X Systems slide, "RoHS LOD: X-50 Mobile vs. Handheld Alpha," no date; and "Innov-X Systems Soil Analyzers, no date.

limits of detection for paper, fabric, and glass samples are similar to non-PVC plastic or a sand matrix.⁷

Table 2 demonstrates that the accuracy of XRF is sufficient to meet the objective of this screening project, that is, to identify samples that exceed the 100 ppm screening threshold for one of the restricted heavy metals, with the exception of non-aluminum metal alloys. The higher limit of detection for non-aluminum alloys (such as steel) and tin-based solder was taken into account when evaluating the screening results for these materials, which represented less than 1 percent of all samples. Equipment calibration and testing followed the Innov-X Systems Alpha Series™ User Instruction Manual.⁸ Two sets of certified reference samples were used to verify instrument performance at the start of each test session and every two hours thereafter. The reference samples included a polyethylene (PE) matrix and a polyvinyl chloride (PVC) matrix that contained known concentrations of the four heavy metals of interest (Pb, Hg, Cd, and Cr⁶) and a blank (no heavy metal concentration). The equipment operator was trained in the safe operation of the Alpha Series™ instrument.

To prepare packaging samples for testing, the products were removed from the packages and individual packaging components were isolated to the extent possible. Samples were either directly measured (non-destructive) or mechanically prepared (e.g., cut in squares and layered; folded) to meet a minimum sample thickness of 5 mm; and positioned directly over the detection window.⁹ The measurement time for all samples was 120 seconds. Duplicate readings, at a minimum, were taken for each packaging component that failed the screening for one or more metals. Only one measurement was taken of samples that passed in order to increase throughput and thereby maximize the number of packaged screened over the course of the test program.

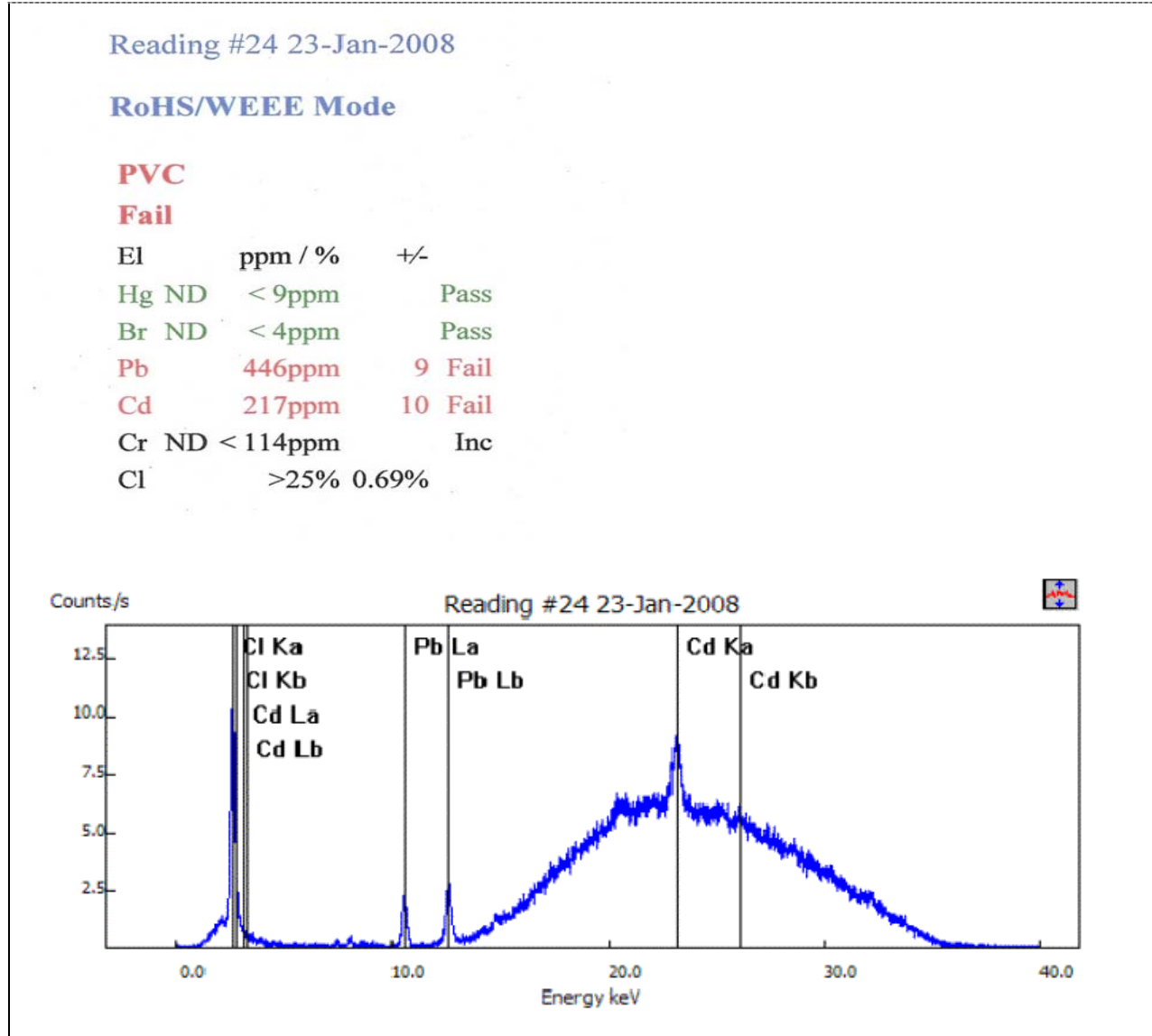
As shown in Figure 4, the analyzer displayed results as the concentration (ppm) level of each element detected in the sample, or indicated that the element was not detected (ND). The reading for each element was accompanied by a range of uncertainty (i.e., +/- error) for the sample, which was expressed in ppm. The instrument also provides the x-ray spectrum for each analyzed sample. For example, the spectral reading below was for a flexible PVC package that

⁷ Personal communication with Monet MacGillivray, Innov-X Systems, Inc., June 18, 2009.

⁸ Innov-X Systems Alpha Series™ User Instruction Manual, March 2007, P/N 100392, Revision B.

⁹ Sample thickness and positioning can also affect the accuracy of XRF readings.

Figure 4: Sample Results and Spectral Reading Generated by Innov-X Systems Alpha Series™ Instrument



contained both lead (Pb) and cadmium (Cd). These measurements, along with the user data inputs, were stored in the instruments software, which cannot be modified, thus ensuring the integrity of test results. The test results were exported into a spreadsheet format for subsequent analysis.

For this project, the concentration of the four metals (cadmium, lead, mercury, and chromium) was evaluated as pass (< 100 ppm or below the limit of detection) or fail (\geq 100 ppm), taking into consideration the reported range of uncertainty for each metal. The test results were compiled and analyzed for trends in compliance and non-compliance with state toxics in packaging laws, including: the percentage of samples that passed and failed the screening test; and the characteristics of failed samples, including product sector, material types and which

restricted metals were detected above the screening threshold. The screening results were also used to initiate dialogue with the manufacturers and distributors of the packaging or packaged product about state toxics in packaging requirements, as discussed further below.

C. Outreach to the Packaging Supply Chain

The TPCCH test program was designed to screen packages. Based on the results of the test program, companies selling or distributing packages that failed the screening test received notification of the test results. TPCCH requested that these companies certify compliance to state toxic in packaging laws and provide supporting analytical data, or notify TPCCH of non-compliant packages and discontinue the sale and distribution of the package. The Certificate of Compliance required a company official to certify to the two requirements of state toxic in packaging laws: 1) the restricted heavy metals were not intentionally added; and 2) if any metals were incidentally present, that the sum of the concentration levels did not exceed 100 ppm.

A Compliance Review Committee comprised of eight of ten TPCCH member states and TPCCH program staff reviewed all company submissions and requested additional information as needed. The objective of the TPCCH outreach was to educate companies and their supply chain about toxics in packaging requirements and to work with them to eliminate the use of heavy metals. Companies that did not respond to the requests were referred to member states for appropriate action, including enforcement.

III. Results

A. XRF Screening Results

TPCCH screened 409 packaging samples between January 15 and March 9, 2008 for the presence of the four restricted metals (lead, cadmium, mercury, and hexavalent chromium) using a portable x-ray fluorescence analyzer. The packages included 628 packaging components such as bottles, bags, boxes, paperboard inserts, labels, caps, inks, and twist ties.

The XRF analyzer detected concentrations of one or more of the restricted heavy metals in excess of 100 ppm in 58 packaging samples (see Table 3), or 14 percent of all samples screened.¹⁰ Since sample selection in this study, in part, targeted those packages with a high incidence of non-compliance in the first screening project, this statistic is likely not indicative of the overall compliance rate of packaging samples on the retail market.

¹⁰ These results include packages that failed the screening test due to total chromium. XRF measures total chromium, not hexavalent chromium. Laboratory testing is needed to determine if the chromium is hexavalent chromium.

Table 3: Summary of All Failed Packaging Samples (i.e., >100 ppm of Restricted Metals)

PKG #	Material Type	Product Category	Origin	Cd	Pb	Hg	Cr
1	PVC (clear)	Home Furnishings	China	397			
2	Plastic with colorant	Shopping Bag	Unknown		441		
3	PVC (clear)	Home Furnishings	China	364			
4	Ink on plastic	Shopping Bag	Unknown		411		199
5	PVC with colorant	Cosmetic/personal care	Unknown	231			
6	Ink on plastic	Produce	Honduras		2,034		681
7	Solder	Cosmetic/personal care	USA		150,388		
8	Plastic with colorant	Art Supplies	China		3,375		1,835
9	Ink on plastic	Shopping Bag	Unknown				131
10	PVC (Clear)	Toys & Games	China	256			
11	PVC (Clear)	Hardware	China	290			
12	PVC (Clear)	Home Furnishings	China	490			
13	PVC (Black)	Shopping Bag	Unknown	403	151		
14	Inks on glass	Beverage	Mexico				6,706 ¹
15	PVC (Clear)	Toys & Games	China	433			
16	PVC (Clear)	Home Furnishings	China	286			
17	PVC (Clear)	Apparel	Unknown	330			
18	Ink on plastic	Apparel	Unknown		137		
19	PVC (Black/white)	Cosmetic/personal care	China	350	14,184		
20	PVC (Clear)	Home Furnishings	China	299			
21	PVC (Clear)	Home Furnishings	China	496			
22	PVC (Clear)	Home Furnishings	China	325			
23	PVC (Clear)	Home Furnishings	China	268			
24	PVC (Clear)	Household Item	China	358			
25	PVC (Clear)	Home Furnishings	Pakistan	500			
26	Ink on plastic	Shopping Bag	Unknown		1,608		251
27	Ink on paper	Shopping bag	Unknown				799
28	Ink on plastic	Office supplies	China		3,399		1,577
29	PVC (Clear)	Sporting Goods	China	207	450		
30	PVC (Clear)	Pet Supplies	Columbia	306	194		
31	PVC (Clear)	Pet Supplies	China	443			
32	Plastic with colorant	Shopping bag	Unknown		2,487		372
33	Ink on rigid plastic	Grocery	Vietnam		775		646
34	PVC (Clear)	Home Furnishings	Unknown	200			
35	PVC (Clear)	Home Furnishings	Israel	137	122		
36	PVC (Clear)	Cosmetic/personal care	China	229			
37	PVC (Clear)	Art Supplies	China	264			
38	Ink on corrugated	Electrical/Electronics	China				150
39	PVC (Clear)	Home Furnishings	China	390			
40	Glass (blue)	Beverage	USA				212 ¹
41	PVC (Clear)	Home Furnishings	China	344			
42	PVC (Clear)	Home Furnishings	China	316			
43	PVC (Clear)	Home Furnishings	Pakistan	648	413		
44	PVC (Clear)	Home Furnishings	Pakistan	497			
45	Ink on paper	Produce Bag	Argentina				200

PKG #	Material Type	Product Category	Origin	Cd	Pb	Hg	Cr
46	Ink on plastic	Produce Bag	USA			170	
47	PVC (Clear)	Pet Supplies	Thailand	417	372		
48	PVC (Clear)	Pet Supplies	China	498			
49	PVC (Clear)	Pet Supplies	China	687			
50	PVC (Clear)	Household Item	Unknown	375			
51	PVC (Clear)	Toys & Games	China	252			
52	PVC (Clear)	Art Supplies	China	358			
53	Ink on plastic	Produce Bag	Columbia		2,083		264
54	PVC (Clear)	Household Item	China	381	180		
55	Ink on plastic	Shopping Bag	Unknown			258	
56	PVC (Clear)	Home Furnishings	China	525			
57	PVC (Clear)	Home Furnishings	China	379			
58	PVC (Clear)	Sporting Goods	Unknown	262			

¹Industry representatives are unfamiliar with any materials used in glass decoration that use the hexavalent form of chromium. They indicate this chromium is most likely chromium oxide (Cr2O3).

With few exceptions, packaging components that failed the screening test (>100 ppm of one or more of the 4 restricted metals) generally fell into three groups: flexible PVC, inks and colorants, and solder used in electronic circuitry. This is certainly not surprising given that the sample selection protocols targeted these types of packaging components.

What is interesting, and likely applicable to the overall packaging supply stream, are the types of packaging materials that passed the screening tests, particularly those sampled in substantial numbers. For example, two materials, paper and plastic, comprised the majority of packaging components in this study at 33 percent and 62 percent, respectively. XRF screening did not detect any of the restricted heavy metals in concentrations greater than 100 ppm in the 209 paper-based packaging components tested. As shown in Table 3, heavy metals were detected in the inks isolated from three paper samples, but not in the paper-based material itself. Similarly, although not shown in Table 3, all semi-rigid PVC packaging components (e.g., blister packs, clamshells, boxes) screened (total of 38 samples) passed the screening tests, in contrast to flexible PVC samples. (As discussed in the next section, 52% of flexible PVC samples failed the screening test.)¹¹

While packaging components made of other materials (e.g., aluminum, steel) did not fail the screening tests, meaningful conclusions are not possible due to the limited number of samples in this study.

Which Metals Were Detected?

Cadmium was the most frequently detected of the four regulated metals, followed by lead (Table 4). All samples containing cadmium were flexible PVC, and over 90 percent of these were imported, based on product labeling. The concentration of cadmium in these samples ranged from 137 ppm to 687 ppm with a median of 358 ppm. Metals, including cadmium and

¹¹ According to a Vinyl Institute report, "Use of Metal Process Additives in the U.S. Vinyl Processing Industry" (October 2007, p.7), metal stabilizers are generally not used in rigid applications as they act as plasticizers and impart physical properties that are not desired in rigid products.

lead compounds, can be used in mixed-metal heat stabilizers to control degradation during processing of PVC resin and light stability during use, according to the Vinyl Institute.¹²

Lead was detected in 19 of the failed packaging samples. The types of packaging materials that contained lead in this study were more diverse than those containing cadmium. Lead was found in inks and colorants, flexible PVC, and solder. The concentration of lead ranged from 122 ppm to 150,388 ppm with a median of 450 ppm. The lead concentrations in PVC were on the lower end, generally falling below 450 ppm, while lead in inks and colorants was more often detected at concentrations above 1,500 ppm. Lead solder used in one packaging application was the outlier at over 150,000 ppm.

Table 4 also indicates that some inks used on packaging may still contain mercury or hexavalent chromium. Mercury, used in the formulation of some red-based pigments, was detected in two packages at concentrations of 170 ppm and 258 ppm. Thirteen of the 14 samples with detected chromium were packaging samples with inks or colorants. While XRF analysis does not differentiate the type of chromium (e.g., trivalent or hexavalent), it is very possible that the chromium detected on some of these packaging samples is hexavalent chromium based on knowledge of industry practices. Hexavalent chromium is used in the formulation of yellow-based lead chromate pigments. Eight of the 13 samples (62 %) contained both lead and chromium, which might indicate the addition of lead chromate. The glass samples, though, are likely to contain chromium oxide (Cr²O³), not hexavalent chromium.¹³

Table 4: Summary of Results >100 ppm by Restricted Heavy Metal

Restricted Metal	Samples with >100 ppm Detected	Mean (ppm)	Median (ppm)	Range (ppm)	Comments
Cadmium	39	364	358	137 - 687	All samples were flexible PVC; at least 36 of the samples were imported
Lead	19	9,642	450	122 - 150,388	Found in inks, flexible PVC, and solder.
Mercury	2	214	214	170 - 258	Both samples were ink.
Chromium ¹	14	1,002	318	131- 6,706	Most samples were inks on plastic, paper, or glass. Chromium was detected in only one glass (blue) sample. ²

¹ XRF measures total chromium, not hexavalent chromium (Cr+6), which is the regulated metal.

² Chromium is most likely chromium oxide (Cr₂O₃).

Where Were the Restricted Metals Detected?

Packaging samples that failed the screening tests fell into three categories: flexible PVC, inks and colorants, and solder used in electronic circuitry. Table 5 breaks down these samples by product sector.

¹² The Vinyl Institute, "Use of Metal Process Additives in the U.S. Vinyl Processing Industry," October 2007.

¹³ Personal communications with Sandy Spence, Society of Glass and Ceramic Decorated Products (SGCDpro), and Andy Bopp, Association of Safe Glass and Ceramic Products (ASGCP).

Table 5: Samples Failing for One or More Metals > 100 ppm by Product Category

Product Category	Total Samples	Samples > 100 ppm	% of Samples >100ppm	Comments on Samples > 100 ppm
Home Furnishings	44	19	43%	All failed samples were flexible PVC; at least 17 packages were imported
Pet Supplies	15	5	33%	All failed samples were imported, flexible PVC
Art Supplies	10	3	30%	2 flexible PVC; one rigid plastic with colorant; all imported
Sporting Goods	7	2	29%	Both flexible PVC; at least 1 imported
Beverage	7	2	29%	2 glass; 1 of which was imported; both likely chromium oxide, not hexavalent chromium
Personal care/cosmetics	15	4	27%	3 failed samples were flexible PVC, at least 2 imported; one was lead solder
Household Items	14	3	21%	All flexible PVC; at least 2 imported
Apparel	13	2	15%	1 flexible PVC, 1 ink; both unknown origin
Produce Bags	36	4	11%	All failed samples resulting from inks; 3 of 4 were imports from Central and South America
Shopping Bags	85	8	9%	All failed samples arising from inks & colorants
- All	78	7	---	
- Plastic	7	1	---	
- Paper				
Toys & Games	36	3	8%	All imported flexible PVC
Office Supplies	12	1	8%	Ink
Electrical/Electronic	15	1	7%	Inks; imported
Hardware	17	1	6%	Imported flexible PVC
Grocery	60	1	2%	Inks; imported
In-store Service Bags (e.g., deli, produce, fish)	10	0	0%	
Mailing/Shipping Envelopes or Bags	8	0	0%	
Fast Food	3	0	0%	
Baby Equipment/Supplies	1	0	0%	
Novelty	1	0	0%	

Flexible PVC, a “heavy-duty” plastic material, is frequently used to package home furnishings, pet supplies, cosmetics, and inexpensive toys. The home furnishings sector (e.g., packaging for sheets, shower curtains, tablecloths) had the highest percentage (19 of 44 samples) of all packages tested that failed the screening test. All failed packages were flexible PVC. At least 17 of the 19 failed samples were imported, while the remaining two did not have country of origin information. Other product sectors with substantial numbers of packages failing due to flexible PVC, mostly imported, included: pet supplies (5 of 15 samples), sporting goods (2 of 7), household items (3 of 14), art supplies (2 of 10),¹⁴ and personal care (3 of 15 samples failed for PVC).¹⁵ All of the flexible PVC samples were bags or pouches with one exception: twist ties used to package a personal care product.

As shown in Table 6, 52% (37 of the 71) of the flexible PVC packages tested exceeded the screening limit of 100 ppm due to excessive levels of cadmium and/or lead. Almost half (48%) of the flexible PVC used to package home furnishing products failed, while over half (63%) of the pet supply products failed. For each of the other product sectors at least half of the packaging samples failed.

Table 6: Analysis of All Flexible PVC Samples

		PASS < 100 ppm for all metals	FAIL > 100 ppm for any one metal
	Total Samples	Samples	Samples
Flexible PVC Packages	71	34	37
Packages by Product Category			
Home Furnishings	40	21	19
Pet Supplies	8	3	5
Toys & Games	4	1	3
Sporting Goods	4	2	2
Cosmetics	4	2	2
Household	4	2	2
Art Supplies	3	1	2
Other	4	2	2

¹⁴ One failed art supply package was not flexible PVC so it is not included here.

¹⁵ One cosmetic/personal care product failed for lead solder in electronic circuitry found in the packaging materials.

Table 7 provides a breakdown of country of origin for the flexible PVC packages. All of the products in flexible PVC packages that had country of origin information were imported, mostly from Asia.

Table 7: Country of Origin for Flexible PVC Samples

Country of Origin	Total Samples	PASS < 100 ppm	FAIL >100 ppm
Asia	56	27	29
Unknown	12	5	7
U.S.	1	1	0
Columbia	1	0	1
Israel	1	0	1

Inks and colorants failing the screening tests were found in packaging from a variety of product sectors as shown in Table 5 above. Topping the list of failed packages due to inks and colorants were shopping bags (8 of 85 or 9%) and produce bags (4 of 36 or 11%). Lead and chromium were the most frequently detected restricted heavy metal in the inks and colorants, but mercury was also detected in two samples. While XRF technology does not differentiate between types of chromium (e.g., trivalent or hexavalent), it is likely that some inks and colorants do contain hexavalent chromium, which is used in the formulation of lead chromate. Of the 17 samples failing for inks and colorants, almost half (8) contained both lead and chromium. In addition, these packaging samples were mostly yellow, orange, or green, all colors that might be fabricated using yellow pigments containing lead chromate.

Similar to the flexible PVC samples, the elevated levels of restricted metals in inks and colorants appear to be largely from imported products.¹⁶ In addition to Asia, the failed packaging samples originated in South and Central America.

B. 2008 XRF Screening Result Compared to 2006

The percentage of failed samples in 2008 was similar to the initial TPCH packaging screening project in 2006. In the initial study, 14 percent of packages failed screening after the removal of samples that likely failed the screening tests due to total chromium or recycled content. That said, a direct comparison of the results of the two studies is not appropriate given the differences in sample selection protocols.

In the 2006 study there were two types of packaging that dominated the samples failing the screening test: 1) imported flexible PVC; and 2) inks and colorants used on shopping/mailling bags. In the 2008 study, TPCH purposely targeted these packaging components for screening. A comparison of the screening results for these packaging materials may illustrate trends in the use of heavy metals in packaging.

Table 8 compares the test results for flexible PVC packaging components and inks and colorants between 2006 and 2008. There was a decrease in the number of packaging components

¹⁶ Countries of origin statistics are not available for shopping and mailing bags since this information was not often printed on the package.

failing the screening tests for the two categories shown: flexible PVC samples and inks and colorants. The reason for the decline cannot likely be determined, but TPCH believes that the work of the Clearinghouse contributed to this improvement. As an outgrowth of the 2006 test program, TPCH undertook significant outreach to industry about state toxics in packaging laws. Outreach included direct contact with companies selling and distributing non-compliant packages, wide distribution of the findings of the 2006 report through press releases and presentations, and the distribution of new fact sheets about toxics in packaging. While making a connection between TPCH outreach and packaging screening results is not possible, TPCH has documented a 75 percent increase in the number of unsolicited inquiries requesting information on state toxics in packaging laws between July 2007, when the initial report was released, and June 2008. TPCH is also aware of several trade associations, including home furnishings and toys, that notified their members of the TPCH findings and screening projects.

Table 8: Comparison of Selected Screening Results in 2006 and 2008

	% Samples Failing Screening (>100 ppm) in 2006	% Samples Failing Screening (>100 ppm) in 2008
Flexible PVC		
All Flexible PVC Samples	61%	52%
Home Furnishings	81%	48%
Pet Supplies	80%	63%
Inks and Colorants		
Shopping Bags	15%	9%
Mailing/Shipping Envelopes/Bags	21%	0%

C. TPCH XRF Results Compared to Laboratory Analysis

TPCH and its member states continued to research appropriate laboratory sample preparation and test methods for determining total concentration of the four heavy metals in packaging. In its 2007 report, [An Assessment of Heavy Metals in Packaging: Screening Results Using a Portable X-Ray Fluorescence Analyzer](#), TPCH began to question packaging test results obtained using common laboratory test methods after numerous companies refuted TPCH XRF screening results.

TPCH sent several packaging samples from the 2006 screening project to the California Department of Toxic Substance Control's (DTSC) analytical laboratory for further testing and validation of TPCH test results. California DTSC analyzed the samples using XRF technology, as well as Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES), a commonly used laboratory analytical technique for determining metals concentration in soil samples. Samples were prepared using [EPA SW-846 3050B](#), which uses nitric acid over a hot plate for sample digestion; the samples were analyzed by ICP-AES (EPA SW-846 6010B). Table 9 summarizes the XRF test results obtained by TPCH, California DTSC, and Oxford Instruments using portable and bench-top energy-dispersive XRF technology¹⁷, as well as the measurements obtained by California DTSC using ICP-AES.

¹⁷ Oxford Instruments is a manufacturer of XRF instruments.

The results were striking. The XRF measurements all indicated that the packages were in violation of state restrictions on heavy metals in packaging, while the ICP-AES results were at least an order of magnitude less than the XRF results. The ICP-AES only detected metal concentrations over 100 ppm when the XRF results indicated concentrations greater than 1,000 ppm.

Table 9: Comparison of TPCCH 2006 Results with California XRF and ICP Analysis (ppm)

Sample Description	Restricted Metal	XRF			ICP-AES
		TPCH NITON XLt 797	CA DTSC ¹ Oxford X-Met 3000TX	Oxford Instruments ² XGT1000	CA DTSC ³
Shopping Bag 1	Pb	1,296	718	1,163	138
	Cr	494	279	161	30.2
Shopping Bag 2	Pb	9,334	12,752	9,203	322
	Cr	2,548	2,188	1,617	71.6
Textile Bag – Flexible PVC	Cd	430	360	591	20.4
	Pb	404	432	565	19.2

- 1 CA DTSC XRF testing was performed using Oxford Instrument, X-MET 3000TX; results are the average of two readings; shopping bag samples were 32 layers thick (2-3 mm); the textile bag was 8 layers thick (1mm).
- 2 Oxford Instruments tested the samples using a bench top energy-dispersive x-ray fluorescence spectrometer, Model XGT 1000WR-Type II.
- 3 Samples were prepared using EPA SW-846 3050B, which uses nitric acid over a hot plate for sample digestion; the samples were analyzed using EPA –846 6010B.

After the release of the 2007 TPCCH report, California DTSC released additional test results comparing several sample digestion methods specified in [EPA SW-846](#), which are discussed and summarized in Box 2, followed by analysis using ICP-AES. As shown in Table 10, the concentration of heavy metals in PVC packages detected by ICP-AES analysis increased when more rigorous sample preparation methods, and specifically the use of microwave assisted acid digestion, were used to digest the sample and liberate the metals from the hard-to-digest PVC matrices. EPA SW-846 Method 3052 achieved the most consistent and comparable results to XRF analysis, while Method 3050B resulted in significantly lower concentrations of heavy metals in all samples tested, compared to Method 3052 and XRF analysis.

Box 2: [EPA SW-846](#) Sample Preparation Methods

State toxics in packaging laws specify that the sum of the four regulated metals – cadmium, lead, mercury and hexavalent chromium -- cannot exceed 100 ppm. The goal of analytical testing therefore is to determine the total concentration of the four regulated metals. For an analytical method to accurately measure the presence and concentration of metal, the metal must be completely liberated from the matrix. Therefore, proper sample preparation is critical to obtain meaningful results. In order to measure the total level of metals in the matrix, the matrix must be completely digested, dissolved, or broken down. The choice of sample preparation depends on the type of sample (matrix).

Many labs use EPA Method 3050B or 3051 for sample preparation. These methods are described as providing “total metals,” however, the methods were designed for hazardous waste and site characterizations. For the purposes of product or package component testing, the goal is to determine the true presence and total concentration of metals in the component because the laws prohibit the intentional *use* and incidental *presence* of the metals. In practice, TPCB has found that these methods are NOT sufficiently aggressive to completely digest/dissolve plastic matrices. In fact, the method summary for EPA Method 3050B states that it is NOT the proper method for preparing samples where *total* metals concentration is desired. Rather, EPA Method 3052 provides an aggressive acid and microwave energy combination to effectively break down the organic matrices. Although EPA Method 3052 prescribes the use of hydrofluoric acid (HF) in some instances, HF is **not** required for effective digestion of typical plastic/PVC type package components. Rather, HF is required ONLY if the matrix is siliceous (i.e., contains silica) in nature.

For other types of matrices such as paper, metal, and some inks, EPA Method 3050B may be appropriate, as long as the matrix is completely digested. Method 3052 may be necessary in order to completely break down organic matrix of some inks.

EPA SW-846 Method 3050B

This method uses nitric acid and hydrogen peroxide added to a representative sample and heated on a hot plate. This method is not a total digestion technique for most samples. It is a very strong acid digestion that will dissolve almost all elements that could become “environmentally available.” By design, elements bound in silicate structures are not normally dissolved by this procedure since they are not usually mobile in the environment. The method may also fail to completely liberate metals bound in polymeric matrices. The method states that, if total digestion is required, use Method 3052.

EPA SW-846 Method 3051A

This is a microwave assisted acid digestion method designed to mimic Method 3050B. Since this method is not intended to accomplish total decomposition of the sample, the extracted analyte concentrations may not reflect the total content in the sample.

EPA SW-846 Method 3052

The scope and application of Method 3052 states that it is applicable to the microwave assisted acid digestion of organic matrices and other complex matrices and that the technique is not appropriate for regulatory applications that require the use of leachate preparations (such as Method 3050). It further states that Method 3052 is appropriate for those applications requiring a total decomposition in response to a regulation that requires total sample decomposition.

Table 10: CA DTSC Comparison of SW-846 Sample Preparation Methods: Concentration (ppm) of Metals in Flexible PVC Packages

Sample	Elements	XRF Screening	3050B/ICP	3051/ICP Microwave	3052/ICP Microwave Vendor A	3052/ICP Microwave Vendor B
1	Cadmium	ND	ND	ND	NA	ND
	Lead	1,300	138	779	NA	1,101
	Chromium	420	30	198	NA	264
2	Cadmium	ND	ND	ND	NA	ND
	Lead	650	74	544	NA	561
	Chromium	ND	18	135	NA	142
3	Cadmium	ND	ND	ND	ND	ND
	Lead	257	154	187	332	305
	Chromium	ND	37	55	143	81

ND = not detected; NA = not applicable

D. Company Responses

The TPCCH test program was designed to screen packages for the presence of the four restricted metals. Based on the results of the test program, companies selling or distributing packages that failed the screening test received notification of the test results in May and June 2008. Companies were requested to certify compliance with state toxics in packaging laws and to provide supporting analytic data, or to notify TPCCH of non-compliant packages and discontinue the sale and distribution of the package.

TPCCH notified 33 companies, accounting for 39 of the 58 packages that failed the XRF screening for one or more restricted heavy metals. Due to limited resources, TPCCH contacted only those companies with packages exceeding 200 ppm for one or a combination of restricted metals.¹⁸ In addition, some companies were contacted directly by member states, rather than TPCCH, and in a few cases TPCCH could not identify or locate the brand owner.

Of the 33 companies notified, 13 companies (39%) confirmed that their packages were not in compliance with state laws, and discontinued the sale and distribution of the package, if

¹⁸ The screening protocol, as depicted in Figure 1, established a 100 ppm pass/fail threshold. Given the number of packages (58) failing the screening test, TPCCH chose to only follow up with companies whose packaging exceeded 200 ppm for one or a combination of restricted metals.

the package was still in the supply pipeline or on retail shelves. Table 11 summarizes the steps taken by 10 of these companies, as reported to TPCH, to prevent the sale and distribution of the non-compliant package.¹⁹ For example, several packaged products were recalled and returned to the manufacturer or distributor for proper disposition of the non-compliant packages.

In two cases, companies notified TPCH that entire shipments of non-compliant packages were prevented from entering the U.S. from overseas. One company alone turned 15 container loads of non-compliant packages away from the U.S. border with a total of 11,324 pounds of plastic bags printed with lead-based inks. Subsequently, the company stopped doing business with the supplier of the non-compliant bag, preventing distribution in the U.S. of almost 5 million bags each year that contained lead in concentrations over 2,000 ppm.

The changes resulting from the TPCH compliance-screening project extend beyond current inventories. Seven of the 10 companies reported source reduction practices, such as changing packaging design, materials, or suppliers, while eight companies developed new quality assurance practices that will result in long term change across multiple products. For example, one major national retailer now requires all of its suppliers to submit Certificates of Compliance in order to sell products in their retail stores, or submit the package for testing to the company's approved vendors. Other companies have established new quality assurance procedures that include random testing of packages to ensure compliance. Conversations with at least one of these companies and their suppliers revealed that these new quality assurance procedures have uncovered additional non-compliant products and corrective actions.

Finally, as a result of the TPCH compliance screening results, most of these companies have communicated, in one way or another, with their supply base about toxics in packaging requirements. Many of these companies have sent letters to all their suppliers about toxics in packaging or revised supplier contracts or packaging specifications to incorporate toxics in packaging requirements.

¹⁹ These actions are only what was reported to TPCH. In addition, some companies are still in the process of addressing packaging issues.

Table 11: Summary of Reported Company Actions for Confirmed Non-Compliant Packages

	1	2	3	4	5	6	7	8	9	10
	Fresh Produce Company	National Retailer 1	National Retailer 2	National Retailer 3	National Retailer 3	National Retailer 4	Home Furnishings Company 1	Home Furnishings Company 2	Personal Care Products Company 1	Seafood Product Company
	Ink on plastic bag	Flexible PVC bag	Flexible PVC bag	Flexible PVC bag	Flexible PVC bag	Colorants in plastic bag	Flexible PVC bag	Flexible PVC bag	PVC twist ties	Ink on rigid plastic
Prevent Sales & Distribution of Non-Compliant Packaging										
Stop Sale & Distribution of current inventory in TPCB States			X		X	X	X		X	
Stop Shipments into US	X								X	
Recall Non-Compliant Packages				X	X	X			X	
Freeze and Dispose of Inventory	X		X	X					X	
Source Reduction Efforts										
Changed Suppliers, Materials or Design	X		X	X	X			X	X	X
Established New QA Procedures	X	X (1)	X	X	X		X	X	X	
Reviewed Other Packaging Supplies/Suppliers	X	X		X	X			X		
Outreach to Suppliers										
Notified or Re-notified Suppliers of Requirement		X (2)		X	X			X (3)		

(1) Random test program for private label packages. (2) Revising supplier contracts to reference toxics in packaging laws; developing educational training program for product development teams & overseas suppliers. (3) Included consequences for shipping non-compliant bags

The 13 companies confirming that their packaging was not in compliance with state laws and then taking concrete actions to eliminate heavy metals from packaging were the success stories of this TPCH screening project. The outcome for the remaining 20 companies notified of non-compliant packaging is shown in Table 12.

Table 12: Company Responses to TPCH Notification of Non-Compliant Packages

Result of TPCH Notification	Number of Companies	Percentage of Companies
Confirmed Non-Compliant Packages and Undertook Corrective Actions	13	39%
Submitted Certificates of Compliance	16	48%
Notified TPCH that Packaging Was No Longer Sold or Distributed	3	<1%
Did Not Reply	2 ⁽¹⁾	<1%

¹ Companies received two notifications from TPCH. If they didn't respond, the file was referred to member states for follow up action and possible enforcement, which typically resulted in a response. Due to limited resources, in these two cases, member states chose not to follow up.

Sixteen companies (48% of companies notified) submitted Certificates of Compliance with supporting documentation to TPCH claiming that their packages were in compliance with state laws. There are several possible explanations for the discrepancy between TPCH test results indicating non-compliance and the companies' claims. First, as discussed in the previous section, testing laboratories may be using inappropriate sample preparation methods for measuring total concentration of heavy metals, resulting in false claims of compliance. Second, anecdotal evidence suggests that suppliers, particularly overseas suppliers, may be submitting false certifications and test results. Third, the packaging material tested by the company might be in compliance, but it is intentionally or unintentionally a different material (i.e., from a different shipment or supplier) than the sample screened by TPCH. Finally, it is possible, but not very likely, that the TPCH screening results are incorrect. This final explanation is least plausible, given that more than a third of the companies notified concurred with TPCH test results for packages with similar materials and heavy metal concentrations as the ones in which companies refuted TPCH screening results. Further, many TPCH XRF results were confirmed by EPA SW846 Method 3052 analyses.

Despite either the claims of compliance or the discontinuance of the suspect packaging, some of these companies chose to implement new or additional quality assurance practices related to toxics in packaging and reinforce toxics in packaging policies with suppliers. For example, one company in the home furnishings industry that manufactures its products in China is now pulling a packaging sample from each of its suppliers for testing on a quarterly basis.

IV. Discussion

A. Making Progress

The results presented above indicate progress in reducing the toxicity of the packaging waste stream and changing industry practices, which will result in long term environmental benefits. Many of the companies contacted about potentially non-compliant packages were nationally recognized brand owners with a tremendous influence on the supply stream. For example, just the companies that acknowledged non-compliant packages and implemented corrective actions, alone have annual sales over \$450 billion. The initiatives of these companies to eliminate heavy metals from their packages and implement new quality assurance procedures had and continue to have a positive ripple effect throughout the packaging supply chain.

Targeted outreach to companies based on actual screening results of the packages they sell and distribute, combined with the potential for state enforcement, proved to be a powerful change agent. It is interesting to note that the 2008 compliance screening results were more readily accepted by and had a much greater impact on companies than the 2006 project results. For example, in 2006 only 15% of the companies contacted confirmed the TPCCH allegation of non-compliance, compared to 39% in 2008. The actions taken by companies to address the packaging violations in 2008 were also more extensive than actions taken by companies in 2006. Several factors may have contributed to this elevated response by companies in 2008, including increased name recognition of TPCCH and awareness of state toxics in packaging requirements arising out of publicity around the 2007 TPCCH screening report. It is also likely, however, that the September 2008 settlement between the California Department of Toxic Substances Control and Forever 21, a mall-based retailer, for alleged violation of toxics in packaging requirements had an impact.²⁰ This settlement, one of the first under any state toxics in packaging law, raised the visibility of toxics in packaging within the regulated community.

If a follow up screening project were launched today, a year after these companies were notified about non-compliant packages, TPCCH would expect to see a significant drop in the percentage of non-compliant packages across the spectrum of retail packaging and in specific product sectors such as home furnishings. Similarly, when conducting compliance monitoring, states would expect to find increased compliance at companies that have received notice from TPCCH.

B. Quality and Compliance Assurance

TPCCH and member states question the continued reliance on supplier assurances and the lack of any procedures to verify compliance, in light of the number of scandals in Asia around tainted products such as lead paint in children's toys. Similarly, many companies claimed that their packaging specifications prohibited the use of the restricted heavy metals, but had no mechanisms in place to monitor whether suppliers were adhering to the specification. As noted above, this may be changing as more companies recognize the potential cost of dealing with non-compliant packages – from recalls to enforcement actions. The TPCCH document, [Quality](#)

²⁰ The heavy metal content of the Forever 21 package was first discovered in the TPCCH 2006 screening project, and was subsequently referred to the State of California for follow up action.

[Assurance Considerations for Toxics in Packaging](#), outlines some key steps to consider when developing a compliance assurance system.

C. Test Methodologies

The comparative analysis of sample preparation methods by the California DTSC demonstrates the importance of selecting appropriate dissolution methods for packaging material, and specifically, flexible PVC matrices. Further, analytic test results submitted by companies claiming compliance with state toxics in packaging laws indicated that testing laboratories may be applying inappropriate sample preparation methods when testing for toxics in packaging.

TPCH and its member states emphasized throughout the screening project and in its communications with regulated entities the importance of sample preparation and requested the use of EPA SW-846 Method 3052 and microwave assisted acid digestion, particularly for hard to dissolve substrates, and will continue to do so. Throughout the screening project, TPCH heard objections to the use of Method 3052, with laboratories arguing that Method 3052 required the use of hydrofluoric acid, an extremely hazardous reagent that they were unwilling to use in their laboratories. However, this argument was unfounded, since Method 3052 only requires the use of hydrofluoric acid when digesting samples containing silica. Hydrofluoric acid is **not** required for effective digestion of typical plastic/PVC type package components.

TPCH will continue to request the use of EPA SW-846 Method 3052 and microwave assisted acid digestion among regulated entities and commercial testing laboratories. This methodology should become more widely accepted and recognized, since the Consumer Product Safety Commission published a similar test method in February 2009 for determining total lead in plastics in children's products.²¹

V. Conclusions

This report documented the continued use and presence of heavy metals, particularly lead and cadmium, in packaging. Some packaging materials and components were still more likely to contain heavy metals than others, namely imported flexible PVC, inks and colorants in shopping bags, and solder used in electronic circuitry.

This compliance-screening project achieved measurable results in the short and long term. As a direct result of TPCH notification of potentially non-compliant packaging, companies took actions that reduced the amount of heavy metals, particularly lead, cadmium and hexavalent chromium, used in packaging, and ultimately from entering the environment through the solid waste stream. Companies prevented the continued sale and distribution of packaging containing these toxic heavy metals, and changed their supply stream to eliminate the future use of these metals. Companies also implemented new quality assurance practices to detect the presence of the restricted metals in incoming packaging materials, which will allow for earlier and less costly

²¹ [Test Method: CPSC-CH-E1002-08](http://www.cpsc.gov/ABOUT/Cpsia/CPSC-CH-E1002-08.pdf), Standard Operating Procedure for Determining Total Lead (Pb) in Non-Metal Children's Products, February 1, 2009, available at <http://www.cpsc.gov/ABOUT/Cpsia/CPSC-CH-E1002-08.pdf>.

corrective action, and embarked on new initiatives to educate and better manage their supply chains.

The ripple effect through the supply chain caused by TPCCH notification letters sent to just 33 companies and the ensuing communications was and continues to be significant. However, more work lies ahead. TPCCH will continue its efforts to reach out to multiple constituents within the packaging supply chain and different product sectors, particularly those identified in this screening project as having a higher likelihood of non-compliance, to educate them about state toxics in packaging requirements. TPCCH and its member states also expect to continue monitoring packaging for compliance with state laws, since XRF screening results have proven to be an extremely effective tool for communicating with regulated entities and sparking change.