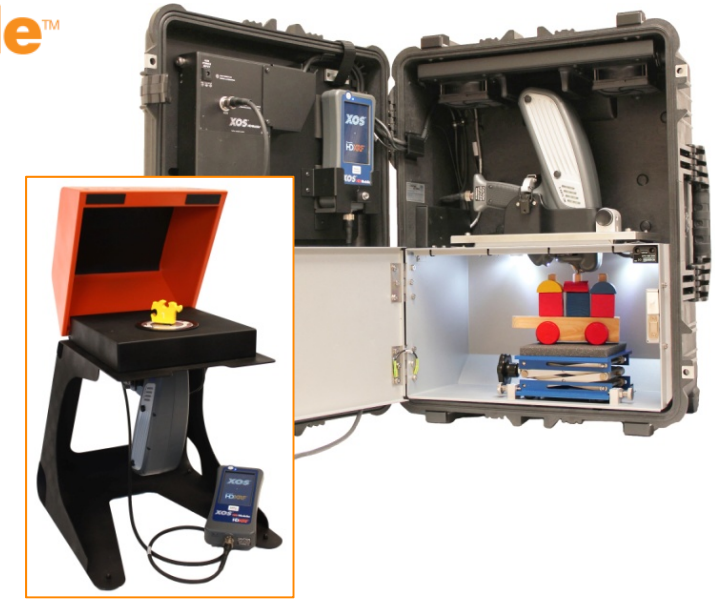
better analysis counts

Intro to HDXRF

HD Mobile™



HD Prime

Agenda

- History/Background of XOS
- Traditional XRF vs. HDXRF
- What is the advantage that XOS/HDXRF offers in the current consumer product market around the world?
- What's next?

© XOS

- **East Greenbush, NY (Albany-area)**
  - Marketing and Sales
  - Manufacturing
  - Engineering
  - R&D
  - Admin

- **Shenzhen, China**
  - Sales
  - In-house and Field Service

- **Regional Sales offices all over the globe**

- **Elemental Analysis by Optic-Enabled XRF**
  - Main business Lines:

Petroleum
- Crude Treatment Sites
- Oil Refineries
- Finished Product Terminals
- Third Party Test Labs (TPLs)
- Regulator

Health & Safety
- Third Party Test Labs (TPLs)
- Production testing (at factory)
- Distribution centers
- Import screening

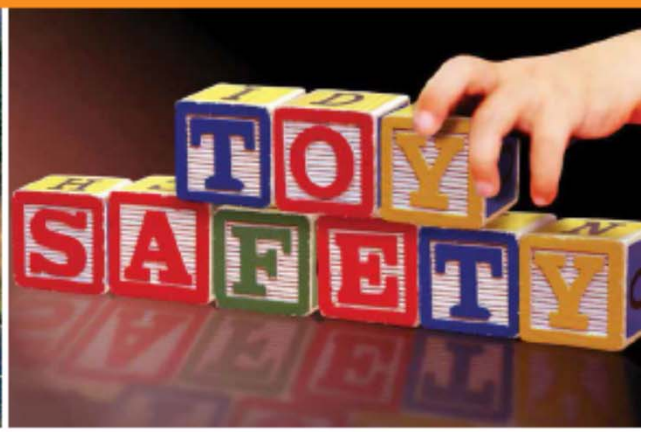
Environmental
- Regulators
- Government
- Engineering firms
- Soil remediation
- Wastewater monitoring
- Third Party Test Labs (TPLs)

OEM
- Original Equipment Mfg that utilize optics & sub-systems

© XOS

XOS®

better analysis counts



Our Mission

Improve **public safety** and **customer efficiency** through insightful material analysis.

Our Vision

Deliver the most innovative elemental analysis safety and efficiency solutions; solutions renowned for their quality, precision, ease-of-use, and testing speed.

1990
- XOS is founded in upstate New York

Mid-90s
- Obtains initial investment and R&D contracts to sell X-ray optics commercially

2001
- Starts to develop subsystems and application-specific analyzers

2003
- Launches the Sindie analyzer, the first instrument sold in volume

2004
- Sindie analyzer is approved by ASTM

2006
- US Clean Air Act mandates 98% reduction of sulfur in on-road diesel products.
- Sindie achieves more than 90% market share in North America

2007
- Develops Clora to measure chlorides in liquid hydrocarbon samples and aqueous solutions

2008
- CPSIA is passed, mandating stricter levels of elements in children's products

2009
- Launches the first HDXRF analyzer to measure lead and other toxins in paint coatings and substrates
- Opens subsidiary in Shenzhen, China

2011
- HDXRF analyzer is approved by CPSC for certification of lead in paint and similar surface coatings
- Launches new FERU and upstream analyzers: benchtop and online
- XOS acquired by Danaher

2013
- Introduces Accu-Flow for continuous flow measurement of petroleum samples
- HDXRF analyzers approved by CPSC for certification of lead in homogenous substrate materials

2015
- Launches soil and wastewater analyzers
- Announces collaboration with the Jet Propulsion Laboratory on the Mars 2020 project

1990 | Mid-90s | 2001 | 2003 | 2004 | 2006 | 2007 | 2008 | 2009 | 2011 | 2013 | 2015

© XOS

XOS MWD XRF Product Portfolio

- **Elements:**
  - Sulfur
  - Chlorine
  - Silicon
  - Phosphorus
- **Product Options:**
  - Benchtop
  - On-line
  - Portable

MWDXRF

XOS MMB-EDXRF Product Portfolio

HD Maxine

HD Prime

HD Mobile

HD Rocksand™

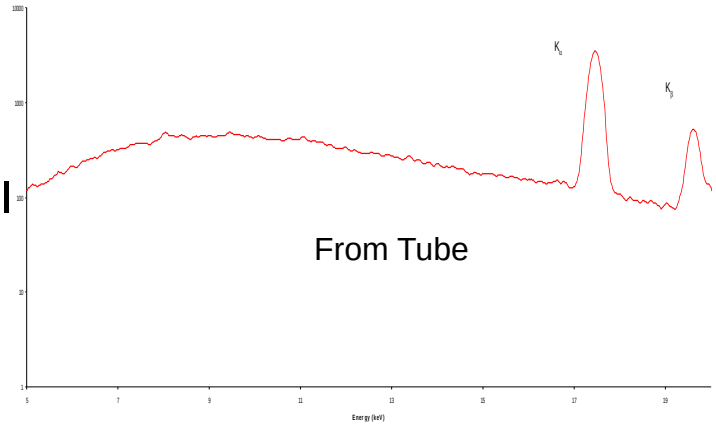
- **Elements:**
  - All HDXRF products provide multi-element analysis
- **Product Options:**
  - Benchtop
  - Portable

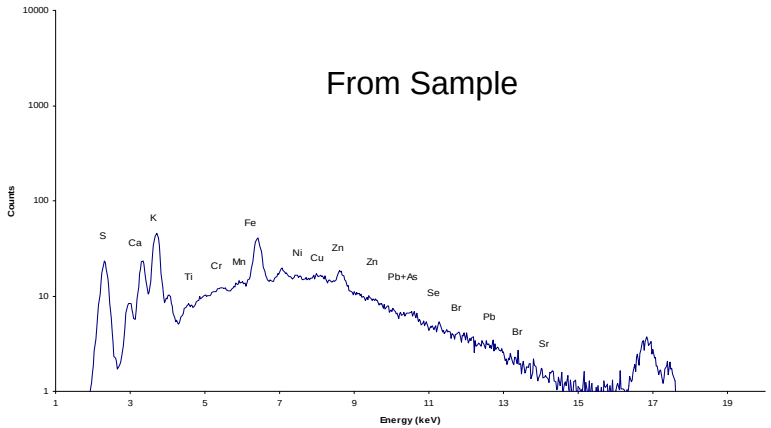
HDXRF®

The HDXRF Advantage

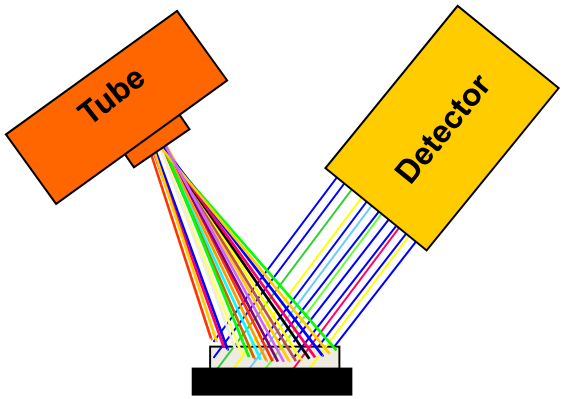
© XOS

Conventional XRF





X-Rays Generated



Secondary X-Rays Detected

Sample

Secondary X-Rays Emitted from sample

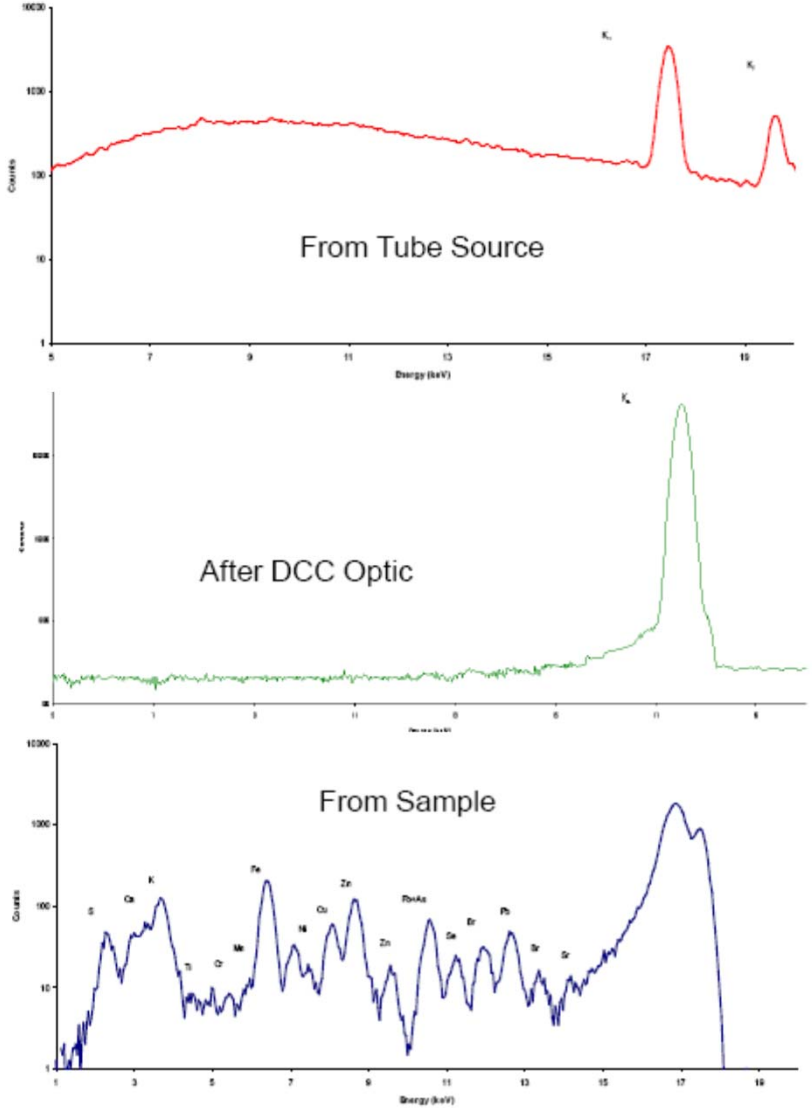
© XOS

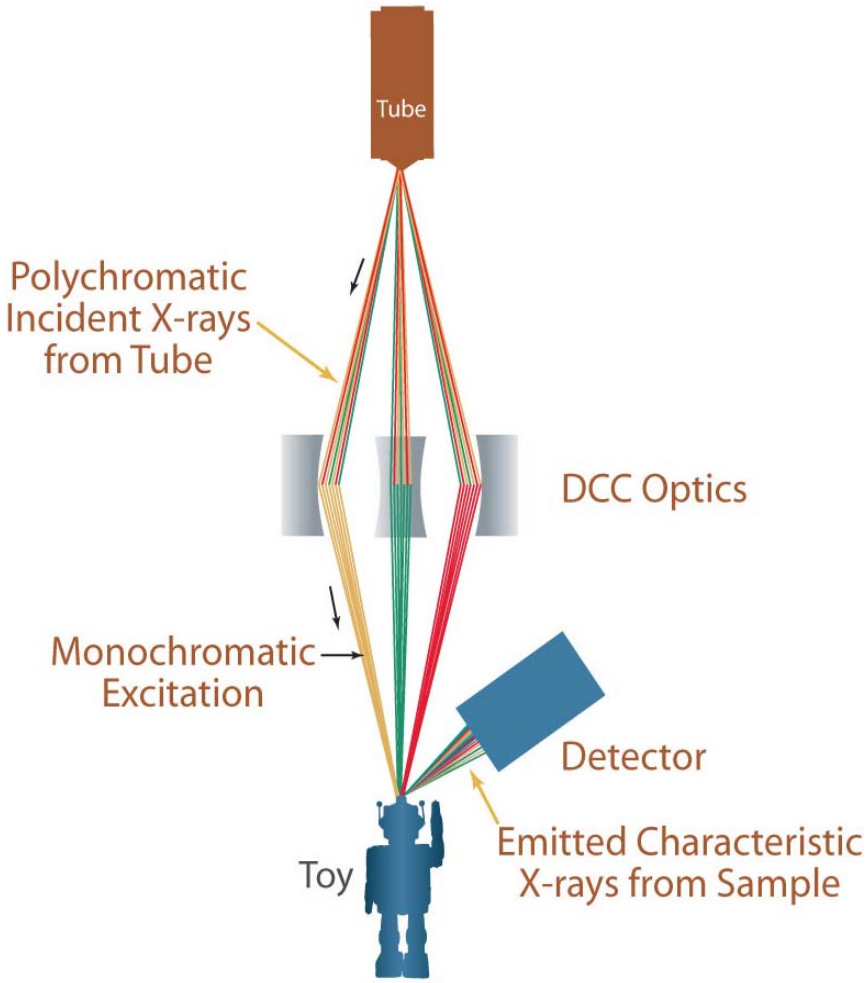
Conventional XRF

- An inexpensive screening option which can be a valuable tool to screen at a high level for material failures
- Difficult to quantify low concentrations of heavy metals, even in substrates or bulk materials due to high background from X-ray source
- Measurement result is an uncontrolled average of the coating *and* the substrate material
- Results for surface coating in $\mu g/cm^2$ or mass per unit area, not the regulated parts per million (ppm)
- Average across multiple features and materials due to large illuminated area

© XOS

HDXRF – principle of operation





Secondary X-Rays Emitted from sample

© XOS

HDXRF

- A screening and quantifying tool which can identify failures as well as verify compliance.
  - An instrument can only verify compliance if it is capable of quantification below the regulatory limit.
- Coating *and* substrate material can be measured separately with a single measurement
- Results for surface coating reported in ppm AND in $\mu g/cm^2$ or mass per unit area
- Reduction of scattering background from x-ray tube source allows for lower limits of detection
- Small but intense 1-mm spot size

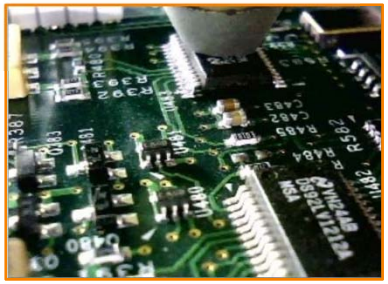
© XOS

What do people use HDXRF for?

- CPSIA compliance per CPSC

…..”ASTM F2853-10, using multiple monochromatic excitation beams for determining Pb content in paint or similar surface coatings on children’s products, is expected to be as effective, precise and reliable as the current CPSC staff method” (wet chemistry)…

- Various State Regulations including California’s Proposition 65
- European Toy Standard EN71-3
- Various Health Canada regulations
- Conflict Minerals
- RoHS2 2011/65/EU
- Other



© XOS

Consumer Product Safety Improvement Act (CPSIA) of 2008 (largely in reaction to large Mattel recall) authorized a variety of new regulations and testing requirements for children's products (primarily intended for 12 yrs and under).

The CPSIA fundamentally changed how product safety is regulated in the United States establishing required testing protocols and limits on heavy metals like lead and cadmium.

ASTM-2853 approved by CPSC in 2011 for compliance testing of lead in Paint and similar surface coatings in accordance with CPSIA.

UNITED STATES OF AMERICA
CONSUMER PRODUCT
SAFETY COMMISSION

http://www.cpsc.gov/about/cpsia/cpsia.html

© XOS

CPSC approval of HDXRF for testing by labs for product certification made it the ONLY alternative test method to "wet chemistry" for paint/surface coatings.

- **Lead in Paint/Surface Coatings**: (90 ppm total) for children's products and household furniture
- **Lead in Substrates**: (100 ppm total) for all accessible components of children's products.
- **Toy Standard**: (ASTM F963-11 mandatory as of 2013) sets total screen threshold and soluble limits for 8 heavy metals (Pb, Cd, Cr, As, Se, Ba, Sb, Se)
- **Children's Jewelry**: (ASTM F2923-11 recognized by CPSC) limits "small parts" in plastics to 75 ppm Cd; 200 µg in metals, and 18µg in "mouthable" parts.

Advantages of HDXRF to ICP for coating analysis:

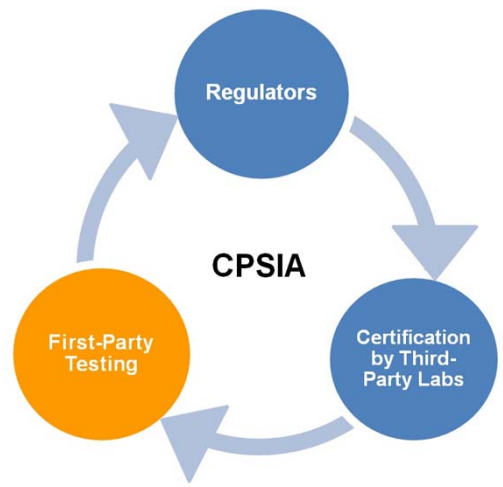
- Little or no sample preparation
- Non-destructive
- Results in minutes

© XOS

"1107 Rule"

- Requires products to be certified by CPSC approved labs and those labs must use CPSC approved test methods
- Requires Periodic Testing (annually) of children's products
  - If manufacturer has a production testing plan in place to ensure a "high degree of assurance" of compliance, 3rd party testing can be done every two years instead of annually.
  - ✯ HDXRF as part of a production testing plan can provide customers with a "high degree of assurance" without increasing testing costs.

Use the same technology relied on by CPSC for compliance



© XOS

Expanded Use of XRF: "1112 Rule"

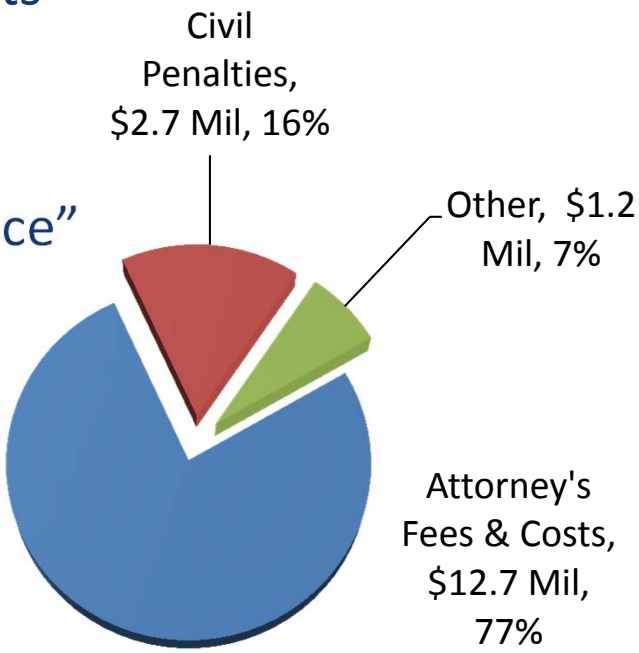
- CPSC Expansion of the "1112 Rule" which took place in Feb 2013 expanded approval of HDXRF for **lead** compliance testing to homogenous substrate materials (with the following additional conditions):
  - Multiple measurements (3) on different locations to ensure spatial homogeneity
  - If the relative st dev of 3 or more XRF measurements of a sample component part exceeds 30%, analysis using "wet chemistry" must be done
  - If any of the XRF measurements (**including the 95% uncertainty**) includes the range with 30% above or below the CPSIA limit, analysis using "wet chemistry" must be done
- Traditional XRF was also approved for lead compliance testing but in addition to the above conditions, daily and substrate-specific calibration must also be performed

© XOS

California Proposition 65

Multiple customers have purchased HDXRF solely for Prop65 testing

- **Labeling/Right to know Legislation**: not a ban, but requires that consumers have "clear and reasonable warning" if they are being exposed to chemicals which are known to cause cancer and/or reproductive toxicity. Exposure vs. content limits
- **~900 restricted elements/chemicals**: including Pb, Cd, As, Hg, Ni, Hex Cr
- **"Minimize Risk"** of being issued a "60-day notice"
- **Cost of non-compliance**: Most 60-day notices result in a settlement. In 2013 there were 352 settlements with payments totaling over 17 million dollars. Average settlement cost is nearly **$50,000**.



© XOS

Conflict Minerals

- 2010 Dodd-Frank Act – Section 1502
- SEC – Security and Exchange Commission ruling requiring companies to investigate their supply chains to determine if they are sourcing any 3TG from conflict mines (in the DRC or "adjoining countries")
- **3T and G** (Tin, Tungsten, Tantalum, & Gold)
- Paper trail legislation, **No Diminimus**
- **Applies to ALL companies who file with the SEC**
  - Must disclose if minerals are necessary to the functionality or production of a product
- If recycled metal and can prove the material is recycled, exempt from filing

© XOS

Canada: Canada Consumer Product Safety Act (CCPSA)

Toy Regulations: SOR/2011-17

- **Contact With Mouth Products**: Products intended to be mouthed and for children (under 3 yrs) play/learning products – 90 ppm lead limit in accessible parts.
- **Surface Coatings of Children's Products** (including toys): 90 ppm total lead limit for children's products including furniture
- **Toys**: 1000 ppm leachable limit in surface coatings for Sb, As, Ba, Cd, and Se.
- **Children's Jewelry**: For lead coating limit is 90 ppm, substrate limit is 600 ppm total/90 ppm leachable; total cadmium limit 130 ppm.
- **Mercury**: total ban on mercury in most consumer products

© XOS

Europe: EN 71-3 2009/48/EC (Toy Safety Directive)

- Previous directive 88/378/EEC was similar to F963 elements/limits.
- Updated standard applies to products entering the European market designed or intended for use in play by children (under 14 yrs) includes migration limits of **19 elements** in three different toy material types

  - Aluminum
  - Antimony
  - Arsenic
  - Barium
  - Boron*
  - Cadmium
  - Chromium (III)*
  - Chromium (VI)*
  - Cobalt
  - Copper
  - Lead
  - Manganese
  - Mercury
  - Nickel
  - Selenium
  - Strontium
  - Tin
  - Organic Tin*
  - Zinc

* XRF is a total elemental content analysis technique. It does not distinguish between valance states (Cr) or type of compount (Sn)

* Boron element is too light for XRF to detect without vacuum system

© XOS

RoHS – 2002/95/EG

- Restriction of the use of certain Hazardous Substances in electrical and electronic equipment went into force July 1, 2006
  - Cadmium, Cd <0.01% (100ppm)
  - Mercury, Hg < 0.1% (1000ppm)
  - Lead, Pb < 0.1% (1000ppm)
  - Hexavalent Chrome, Cr VI < 0.1% (1000ppm)
  - Polybrominated biphenyl, PBB < 0.1% (1000ppm)
  - Polybrominated diphenyl ether, PBDE < 0.1% (1000ppm)
- Applies to goods sold in the EU
- Member states responsible for market surveillance and enforcement.

© XOS

RoHS2 – 2011/65/EU

- Major revision in 2011 resulting in RoHS2
- Main changes in RoHS2:
  - Wider Scope
  - Cat 8 medical devices and: previously exempt, now must comply
  - Cat 9 monitoring and control: previously exempt, now must comply
  - Harmonized with CE documentation and marking
- No change to substances regulated or their limits.

© XOS

How does HDXRF help businesses?

High Definition X-Ray Fluorescence (HDXRF®) for enhanced measurement and precision using patented DCC optics

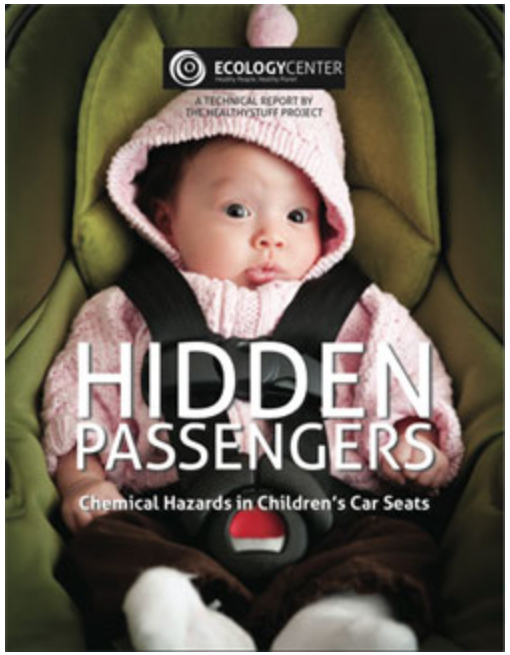
- **Mitigate risk** while maintaining a **high degree of assurance** that products are safe and compliant
- Reduced risk of product recalls and returns
- Can be an integral part of a **production testing plan**
- Lower inventory costs due to quick turnaround time and non-destructive testing
- **Test more without increasing costs**
- Help quickly and efficiently select and **approve new materials/suppliers**

"Results similar to wet chemistry in minutes"

© XOS

Case Study

- HealthyStuff.org published a technical report in which they used HDXRF to screen car seat components for Phosphorus, Chlorine, and Bromine as indicators for restricted flame retardants.



- 114 components from 15 seats scanned by HDXRF. 35 components were selected for GC/MS analysis
- "Overall, the correspondence between the two methods was very good for all three classes of flame retardants."

© XOS

Correlation results

		# of Samples	HDXRF					
			Br	Cl+P	P	Br+Cl+P	Br+P	No Br, Cl, or P
GC/MS	BFR	8	5				3*	
	C/PFR	4		3		1**		
	PFR	10			9			1
	BFR+C/PFR	1				1		
	BFR+PFR	2			1		1	
	No Known FR	11			1			10

* These three samples were correctly identified by XRF as containing Br

** This sample was correctly identified by XRF as containing Cl and P

	Br detected	Br not detected	Cl detected	Cl Not detected	P detected	P not detected
BFR detected	91%					
BFR Not detected		96%				
CFR detected			100%			
CFR Not detected				97%		
PFR detected					94%	
PFR Not detected						79%

© XOS

© XOS

Thank You

For additional information

www.xos.com/hdxrf

info@xos.com

© XOS