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ECOLOGY
State of Washington

Quality Assurance Project Plan

Supplemental Analysis of Flame Retardants in General Consumer and Children's Products

June 2014

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Publication Information

Each study conducted by the Washington State Department of Ecology (Ecology) must have an approved Quality Assurance Project Plan. The plan describes the objectives of the study and the procedures to be followed to achieve those objectives. After completing the study, Ecology will post the final report of the study to the Internet.

This Quality Assurance Project Plan is available on Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1403111.html

Data for this project are available from the project manager, Callie Mathieu callie.mathieu@ecy.wa.gov, upon request. Ecology is currently in the process of developing a database to store product testing data, which is anticipated to be available to the public in August 2014.

Ecology's Activity Tracker Code for this study is 15-008.

Author and Contact Information

Callie Mathieu
P.O. Box 47600
Environmental Assessment Program
Washington State Department of Ecology
Olympia, WA 98504-7710

For more information contact: Communications Consultant, phone 360-407-6834.

Washington State Department of Ecology - www.ecy.wa.gov

- Headquarters, Olympia 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Olympia 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

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Quality Assurance Project Plan

Supplemental Analysis of Flame Retardants in General Consumer and Children's Products

June 2014

Approved by:

Signature: Date: June 2014
Saskia van Bergen, Client, HWTR Program

Signature: Date: June 2014
Ken Zarker, Client's Section Manager, HWTR Program

Signature: Date: June 2014
Callie Mathieu, Author / Project Manager, EAP

Signature: Date: June 2014
Kate Nagel, Project Assistant, HWTR Program

Signature: Date: June 2014
Dale Norton, Author's Unit Supervisor, EAP

Signature: Date: June 2014
Will Kendra, Author's Section Manager, EAP

Signature: Date: June 2014
Joel Bird, Director, Manchester Environmental Laboratory

Signature: Date: June 2014
Bill Kammin, Ecology Quality Assurance Officer

Signatures are not available on the Internet version.
EAP: Environmental Assessment Program
HWTR: Hazardous Waste Toxics Reduction

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Abstract

In early 2014, the Washington State legislature directed the Washington State Department of Ecology (Ecology) to test flame retardants in children's products and furniture and conduct a review of antimony trioxide, tetrabromobisphenol A (TBBPA), and a broader suite of flame retardants. The testing results and literature review will be used to make recommendations to the legislature on whether to restrict or ban the flame retardants in children's products and furniture. The agency determined that supplemental testing of flame retardants in consumer products was needed to fulfill requirements of the report to the legislature.

Ecology carried out a study in 2012/2013 to assess flame retardants in consumer products. In 2014, Ecology will conduct supplemental testing to: (1) evaluate flame retardants in consumer products that were not analyzed in the previous study, and (2) help characterize whether flame retardants identified in the 2012/2013 study are still present in products purchased in 2014.

Ecology will send 40 archived samples from the 2012/2013 study to a laboratory for analysis of antimony (as an indicator of antimony trioxide). Three archived samples will be sent to a laboratory for qualitative analysis (presence/absence) of 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB) and bis(2-ethylhexyl)-2,3,4,5-tetrabromophthalate (TBPH). Samples selected for analysis will be chosen based on data from the 2012/2013 study that indicate likelihood of their presence in the products. Antimony, TBB, and TBPH were not analyzed in the previous study and are being tested now to fill data gaps.

Up to 20 new products will be purchased from stores in the Olympia, Washington area for analysis of tris(1,3-dichloro-2-propyl) phosphate (TDCPP), tris(2-chloroethyl) phosphate (TCEP), tris(1-chloro-2-propyl) phosphate (TCPP), and triphenyl phosphate (TPP). Product types will include baby changing pads, changing mats, and infant sleep positioners containing an inner foam layer. The 2012/2013 study found these product types were likely to contain flame retardants. Data from products purchased in 2014 will be used to help assess whether flame retardants identified in 2012/2013 foam products are still being used.

Background

In early 2014, the Washington State legislature passed a supplemental budget package for ongoing product testing by Ecology to support enforcement of laws that address toxic chemicals and metals in consumer products. The adopted budget included a proviso that directed Ecology to provide a report to the legislature on flame retardants by December 31, 2014. The report must include testing results of flame retardants in children's products and furniture, a review of information such as hazards, uses, exposures, potential health and environmental concerns, safer alternatives, and existing regulatory programs, and make recommendations on whether to restrict or ban the flame retardants in children's products and furniture. Two chemicals that were specifically identified for review were antimony trioxide, which is commonly used as a synergist with halogenated flame retardants, and tetrabromobisphenol A (TBBPA).

The Washington State Department of Ecology (Ecology) carried out a study on flame retardants in general consumer and children's products in 2012/2013 (van Bergen and Stone, 2014), which largely addressed requirements of the proviso. After a data compilation and review, Ecology decided that additional testing and sampling was necessary to fulfill requirements of the proviso. This abbreviated Quality Assurance Project Plan addresses data gaps identified and the need for updated information.

2012/2013 Ecology Flame Retardants Study

Ecology's 2012/2013 study assessed flame retardants in 163 samples from 125 products purchased in Washington State (van Bergen and Stone, 2014). Products such as seat cushions, mattresses, children's furniture, electronics, and foam baby products were screened with an X-ray fluorescence (XRF) analyzer and sent to the laboratory for the analysis of brominated, chlorinated, and phosphorus-based flame retardants. The results showed that many children's foam products contained tris(1,3-dichloro-2-propyl) phosphate (TDCPP), tris(2-chloroethyl) phosphate (TCEP), tris(1-chloro-2-propyl) phosphate (TCPP), and triphenyl phosphate (TPP). One of the recommendations from the study was follow-up sampling and analysis of children's foam products, and inclusion of a commonly used flame retardant in foam, Firemaster 550©, which was not included on the original target analyte list.

Data Compilation and Review

In April 2014, Ecology reviewed available data on flame retardants in consumer products from the 2012/2013 Ecology study, peer-reviewed literature studies, Washington State manufacturer-reported data, and other government agency reports to assess whether additional sampling was necessary to fulfill requirements of the proviso. Ecology compiled a list of 32 flame retardants with the potential to be used in children's products (e.g., plastic electronic casings) or furniture (e.g., foam and textiles). The list was then narrowed to 14 flame retardants that had been measured in indoor dust, using this as an indicator that there is potential for human exposure to the chemicals. The legislature had specifically asked for a review of antimony trioxide, so this

compound was added to the list even though no study was found documenting its presence in indoor dust. A list of the 15 reviewed flame retardants is presented in Appendix A.

Seven compounds from this list were identified as having data gaps because they were not included on the 2012/2013 Ecology study analyte list. Commercial and government laboratories were contacted to determine if capabilities existed for analysis of the seven flame retardants within the timeframe given. Of these, antimony – as an indicator of antimony trioxide – was the only compound with readily available quantification methods. A laboratory was identified with capabilities for qualitative analysis of 2-ethylhexyl-2,3,4,5-tetrabromobenzoate (TBB) and bis(2-ethylhexyl)-2,3,4,5-tetrabromophthalate (TBPH) in foam. Laboratories responded that they did not have existing methods for analysis of the other four compounds in product matrices – resorcinol-bis(diphenylphosphate), 1,2-bis(2,4,6-tribromophenoxy)ethane, bisphenol A bis(diphenyl phosphate), and Dechlorane Plus. Therefore, Ecology made the decision to test antimony, TBB, and TBPH in archived material from the 2012/2013 study.

The data compilation and review also identified the need for updated information on flame retardants in consumer products. The previous Ecology study tested products that were purchased in 2012 and 2013. Because flame retardant usage by manufacturers in foam and furniture may be changing due to an update in California's furniture flammability standard that took effect January 2014 (TB117-2013), Ecology decided to purchase new foam products in 2014 to help assess whether the flame retardants identified in 2012/2013 are still being used. Manufacturers have until January 2015 to comply with the new standard, which neither prohibits nor requires the use of chemical flame retardants in furniture. Baby foam products – changing pads, changing mats, and sleep positioners – were chosen for 2014 testing because of the high frequency of flame retardants found in these product types in the previous Ecology study. The 2012/2013 study tested five samples from these product types and found TDCPP, TCPP, and TCEP in four of them (80% detection frequency).

Project Description

Follow-up testing and sampling of flame retardants in consumer products will be conducted to support a 2014 report to the Washington State legislature on flame retardants. The report will consist of flame retardant testing results, a literature review, and recommendations on whether to restrict or ban flame retardants in children's products and furniture. The following activities will be carried out by Ecology staff and results will be included in the report to the legislature:

- Archived product samples from the 2012/2013 flame retardant study will be sent to a laboratory for analysis of antimony (as an indicator for antimony trioxide (ATO)).
- Archived product samples from the 2012/2013 flame retardant study will be sent to a laboratory for qualitative (presence/absence) analysis of TBB and TBPH.
- Up to 20 new products will be purchased, screened with an XRF analyzer, and sent to a laboratory for analysis of TCEP, TCPP, TDCPP, and TPP.

Goals and Objectives

Antimony Trioxide

Goals

- Gain information on the use of ATO as a synergist for halogenated flame retardants in consumer products.
- Fulfill legislative requirements directing Ecology to review the use of ATO in children's products and furniture.

Objectives

Ecology will send archived product samples from the 2012/2013 study that contained XRF-measured levels of antimony above 2,000 parts per million (ppm), as well as samples with low-level XRF measurements, to Manchester Environmental Laboratory (MEL) for analysis of antimony. Antimony trioxide is used as a flame retardant synergist in polymers at levels ranging from 15,000 - 120,000 ppm (USGS, 2004); however, the lower level of 2,000 ppm was chosen as a cut-off point because the error in XRF measurements is unknown.

TBB and TBPH

Goals

- Fill data gap identified by the agency for presence of flame retardants in consumer products sold in Washington State (see Appendix A for data gap compilation table).
- Support fulfillment of legislative requirements directing Ecology to test for the presence of flame retardants in children's products and furniture.

Objectives

Ecology will send three archived children's foam samples to Duke University's Superfund Research Center for qualitative (presence/absence) analysis of TBB and TBPH. These three samples contained >1% XRF-measured bromine, along with laboratory-detected TPP, indicating that the samples potentially contained the commercial flame retardant, Firemaster 550©. Firemaster 550© is a technical mixture that includes the compounds TBB, TBPH, and TPP (Stapleton et al., 2008).

TCEP, TCPP, TDCPP, and TPP

Goals

- Gain up-to-date information on flame retardants used in children's foam products.
- Determine if manufacturers are still using flame retardants that were identified in children's foam purchased 1-2 years ago.
- Support fulfillment of legislative requirements directing Ecology to test for the presence of flame retardants in children's products and furniture.

Objectives

Ecology will attempt to purchase all changing mats, changing pads, and sleep positioners containing an inner foam layer available in-store from retailers in the Olympia, Washington area. These product types were chosen because of the high detection frequency of flame retardants found in the same product types during the 2012/2013 study. Ecology staff will perform an XRF screening of chlorine and bromine on all collected products and send up to 20 samples to MEL for analysis of TCEP, TCPP, TDCPP, and TPP. This suite covers the known major flame retardants or potential indicators of known major flame retardants identified in polyurethane foam after the phase out of PBDEs.

Organization and Schedule

Table 1 lists the people involved in this project. All are employees of the Washington State Department of Ecology. Table 2 presents the proposed schedule for this project.

Table 1. Organization of project staff and responsibilities.

Staff	Title	Responsibilities
Saskia van Bergen HWTR Program Phone: 360-407-6609	Client	Clarifies the scope of the project. Provides internal review of the QAPP and approves the final QAPP.
Callie Mathieu Toxics Studies Unit SCS, EAP Phone: 360-407-6965	Project Manager	Writes the QAPP. Oversees product collection, processing, and transportation of samples to the laboratory. Conducts QA review of data, analyzes and interprets data. Writes the data into report to legislature. Enters data into Product Testing Database.
Kate Nagel HWTR Program Phone: 360-407-7601	Project Assistant	Helps collect product samples and conducts XRF screening of products.
Dale Norton Toxics Studies Unit SCS, EAP Phone: 360-407-6765	Unit Supervisor for the Project Manager	Provides internal review of the QAPP, approves the budget, and approves the final QAPP.
Will Kendra SCS, EAP Phone: 360-407-6698	Section Manager for the Project Manager	Reviews the project scope and budget, tracks progress, reviews the draft QAPP, and approves the final QAPP.
Joel Bird Manchester Environmental Laboratory Phone: 360-871-8801	Director	Approves the final QAPP.
William R. Kammin Phone: 360-407-6964	Ecology Quality Assurance Officer	Reviews and approves the draft QAPP and the final QAPP.

EAP: Environmental Assessment Program
HWTR: Hazardous Waste and Toxics Reduction
SCS: Statewide Coordination Section
QAPP: Quality Assurance Project Plan

Table 2. Proposed schedule for completing field and laboratory work, data entry into Ecology's Product Testing Database, and the final results included in the report to the legislature.

Product collection and laboratory work	Due date	Lead staff
Product collection completed	06/2014	Callie Mathieu
Laboratory analyses completed	08/2014	
Product Testing Database (PTDB) entry		
	Due date	Lead staff
Product and lab data loaded	10/2014	Callie Mathieu
Database quality assurance review	11/2014	Saskia van Bergen
Data entry complete	12/2014	Callie Mathieu
Inclusion of Data in Report to Legislature		
Author Lead		Callie Mathieu
Schedule		
Draft due to report team	09/2014	Callie Mathieu

Study Design

Ecology staff will review XRF and laboratory data from the 2012/2013 study to determine which archived samples will be sent to MEL for analysis of antimony and which samples will be sent to Duke University's Superfund Research Center for qualitative analysis of TBB and TBPH. Samples will be sent to the respective laboratories in June 2014. Archive samples selected for antimony analysis will be those with the highest XRF-measured antimony levels (>2,000 ppm), as well as several low-level (<2,000 ppm) samples. Archived samples that contained laboratory-detected TPP and XRF-measured bromine (>10,000 ppm) will be forwarded for TBB and TBPH analysis.

Ecology will purchase new baby changing pads, changing mats, and sleep positioners that contain an inner foam layer. They will be purchased from retailers in the Olympia, Washington area. Ecology will buy all products of these types that are available in these stores, in an effort to characterize flame retardant usage in these product types. Products will be brought back to Ecology headquarters, isolated into separate components and screened for bromine and chlorine using an XRF analyzer. Up to 20 products containing the highest XRF-measured bromine and chlorine readings will be sent to the laboratory for analysis of TCEP, TCPP, TDCPP, and TPP.

XRF screening and preparation of the new product samples will follow Ecology's Standard Operating Procedure for Product Sampling (van Bergen, 2014). A brief description of the process and details specific to this study are included in the sections below.

Product Collection

Ecology staff will purchase products "off the shelf" from large-chain retail stores in the Olympia, Washington area. The practice of statewide distribution by most of the retail chain stores ensures that products purchased from local stores are representative of products sold statewide. Products purchased will consist solely of baby changing pads, changing mats, and infant sleep positioners containing an inner layer of foam. An effort will be made to purchase all products available in the store that meet this description.

After products are collected, they will be brought back to Ecology headquarters and assigned a unique sample identification number. Photos, descriptive notes, and purchase receipts will be recorded. Information such as the type of advertisement used to sell the product and where in the store the product was located will also be recorded to help ensure the product was intended for the specific age group.

Product Isolation and Processing

Ecology staff will remove products from their original packaging and isolate individual product components prior to XRF screening and laboratory testing. Isolation of product components will consist of identifying areas of separate colors, textures, or material. Ecology staff will reduce the product component (i.e., inner foam) in size by cutting the material into approximately 4 cm x 4 cm pieces using stainless steel tools (such as scissors, snips, or knives). Sample pieces will be stored in individually-labeled 8 ounce certified-clean glass jars.

Chain-of-custody will be recorded throughout sample processing, screening, shipment, and laboratory analysis. Samples will be processed on a clean bench lined with aluminum foil by staff wearing powder-free nitrile gloves. Tools will be decontaminated at the beginning and ending of each day by scrubbing with Liquinox© and rinsing with deionized water. Between samples, isopropyl alcohol wipes will be used to clean the tools.

XRF Screening and Sample Selection

All isolated product components will be screened using a Niton XL3 XRF analyzer following the instrument manufacturer recommendations and Ecology procedures described in its standard operating procedure for product testing (van Bergen, 2014). XRF measurements will be made on components placed inside a bench-top stand for 120-second intervals. A previous Ecology study found that XRF measurements could be useful as a screening tool to identify products that warrant further laboratory analysis, provided the product is separated into isolated components first and measured in a stand for at least 60 seconds (Furl et al., 2012).

Sample Preparation

MEL staff will attempt to cryomill foam samples before analysis. Cryomilling is the process of reducing a sample to very small particle sizes (~5-50 microns) by lowering the product to cryogenic temperatures and mechanically milling it with a stainless steel magnetic shaker. This process provides a homogenous, finely divided solids sample necessary for efficient extraction. Manchester Environmental Laboratory (MEL) will conduct the cryomilling on all samples where physically possible.

Archived samples are already cryomilled and will be sent to MEL (for antimony) and Duke University (for TBB/TBPH) in the labeled glass jars they are currently stored in.

Measurement Procedures

Laboratory Analysis

MEL will conduct the analyses described in Table 3. Anticipated project reporting limits for plastic and foam matrices are included in the table. It is important to note that reporting limits are matrix-dependent; the limits may not be achievable for all samples, depending on matrix effects.

Samples sent for TBB and TBPH will be analyzed by Duke University's Superfund Research Center under a laboratory-specific method using gas chromatography electron capture negative chemical ionization. Only presence/absence >1% will be reported to Ecology. No commercial laboratory was found to offer quantitative analysis of TBB and TBPH at the time of project plan development.

Table 3. MEL laboratory methods and reporting limits.

Analyte	Matrix	Preparation Method	Analysis Method	Analysis Instrument	MRL (mg/kg)	Expected Range of Results (mg/kg)
Antimony	Plastic	EPA 3052^	EPA 200.8	ICP-MS	0.2	<MRL - 80,000
TCEP	Foam	EPA 3546 Mod.	EPA 8270D Mod.	GC/MS	100	<MRL - 50,000
TCPP	Foam	EPA 3546 Mod.	EPA 8270D Mod.	GC/MS	100	<MRL - 50,000
TDCPP	Foam	EPA 3546 Mod.	EPA 8270D Mod.	GC/MS	100	<MRL - 50,000
TPP	Foam	EPA 3546 Mod.	EPA 8270D Mod.	GC/MS	100	<MRL - 50,000

^ Alternate digestion method without hydrofluoric acid.

MRL = Method Reporting Limit; EPA = Environmental Protection Agency; ICP-MS = Inductively Coupled Plasma-Mass Spectroscopy; GC/MS = Gas Chromatography-Mass Spectroscopy.

Budget

The product collection and laboratory costs estimated for this project totals $11,500. Table 4 shows the product collection and laboratory cost breakdown. TBB and TBPH analyses are not included in this table because there is no cost for the qualitative analysis. The research center carrying out the analysis provides this service free of charge to the public with funding support provided by the National Institute of Environmental Health Sciences. Ecology will be submitting samples to the research center as a member of the public; no contract or agreement will be made between Ecology and the research center.

Table 4. Project budget.

Analysis/Activity	Number of Samples	QC Samples*	Cost per Sample	Total Cost
Antimony	40	2	$50	$2,100
Product Collection	20	n/a	$30	$600
TCEP, TCPP, TDCPP, TPP	20	2	$300	$6,600
cryomilling	20	2	$100	$2,200
			Total Lab Cost	$11,500

*QC (Quality Control) samples in this table include those that are not provided free of charge, including matrix spikes, lab duplicates, and cryomill rinseates.
n/a = not applicable

Quality Control Procedures

Laboratory

Table 5 outlines the laboratory quality control (QC) samples planned at MEL for this project. QC tests will include one method blank, laboratory control sample (LCS), LCS duplicate, and laboratory duplicate per analysis batch of 20 samples or less. Analysis of antimony will include a matrix spike per batch of 20 or less. A surrogate will be run with every sample for TCEP, TCPP, TDCPP, and TPP analyses.

Laboratory QC procedures for cryomilling preparation will include: (1) rinsing the cryomill with deionized water and reagents specified by MEL between each sample and (2) testing a rinse blank per batch of 20 samples processed. One cryomill rinseate per batch will be analyzed for TCEP, TCPP, TDCPP, and TPP.

Table 5. MEL quality control tests.

Analyte	Cryomill Rinseates	Method Blank	Matrix Spike	LCS	LCS Duplicate	Laboratory Duplicate	Surrogate
Antimony	n/a	1/batch	1/batch	1/batch	1/batch	1/batch	---
TCEP	1/batch	1/batch	---	1/batch	1/batch	1/batch	every sample
TCPP	1/batch	1/batch	---	1/batch	1/batch	1/batch	every sample
TDCPP	1/batch	1/batch	---	1/batch	1/batch	1/batch	every sample
TPP	1/batch	1/batch	---	1/batch	1/batch	1/batch	every sample

Batch = 20 samples or fewer.
n/a = not applicable (samples sent for antimony analysis are archived material previously cryomilled).

QC tests for TBB and TBPH are not outlined here, because the research center carrying out the analysis will follow their own QC protocols and are not required to provide those results to Ecology. Ecology will make the assumption that the reported qualitative results are valid and usable for the purposes of the study unless the research center reports an issue with the data quality.

XRF QC will include measurement of metal and plastic duplicates and standards (provided by the manufacturer) after every 25 samples. Since the XRF analysis is being used as a screening tool only, no XRF measurement quality objectives (MQOs) are outlined in this project plan.

Quality Objectives

Quality objectives for this project are to obtain data of sufficient quality for confident quantification of the target chemicals in products and to ensure that results are comparable between products. Objectives will be achieved through careful attention to the sampling, sample processing, measurement, and quality control procedures described in this plan.

Measurement Quality Objectives

Table 6 shows the MQOs for laboratory analysis of the target analytes performed by MEL. MEL will be expected to meet these criteria. However, analyses on consumer products are heavily matrix-dependent and MQOs cannot always be achieved. Quality control tests falling outside of MQO acceptance limits, and related data batches, will be reviewed by the project manager for their usability.

Table 6. MEL measurement quality objectives for laboratory analyses.

Analyte	MRL (mg/kg)	Matrix Spike (recovery)	LCS (recovery)	LCS Duplicate (RPD)	Laboratory Duplicate (RPD)	Surrogate (recovery)
Antimony	0.2	75 - 125%	85 - 115%	≤ 20%	≤ 20%	---
TCEP	100	---	50 - 150%	≤ 40%	≤ 40%	---
TCPP	100	---	50 - 150%	≤ 40%	≤ 40%	---
TDCPP	100	---	50 - 150%	≤ 40%	≤ 40%	---
TPP	100	---	50 - 150%	≤ 40%	≤ 40%	---
Triphenyl Phosphate-d15*	---	---	---	---	---	50 - 150%

MRL = Method Reporting Limit
LCS = Laboratory Control Samples
RPD = Relative Percent Difference
*Surrogate compound for TCEP, TCPP, TDCPP, and TPP analyses.

Data Management Procedures

All project data will be stored in Ecology's Product Testing Database, with the exception of the presence/absence results for TBB and TBPH. The database is not formatted for this type of data. Product descriptions, purchase receipts, photos of products, XRF data, laboratory data and case narratives will be stored in the database. The public will have access to laboratory results and product information through the public interface search tool, which is anticipated to be ready by August 2014.

Audits and Reports

Audits

MEL must participate in performance and system audits of their routine procedures. Results of these audits will be available upon request.

Report

Final results will be included in the 2014 report to the legislature on flame retardants. Laboratory data will also be available to the public on the Product Testing Database, with the exception of TBB and TBPH presence/absence results.

Data Verification and Validation

MEL will verify that (1) methods and protocols specified in this project plan were followed, (2) all calibrations, QC tests, and intermediate calculations were performed for all samples, and (3) the data are consistent, correct, and complete, with no errors or omissions. Evaluation criteria will include the acceptability of procedural blanks, calibration, ion abundance ratios, QC tests, and appropriateness of data qualifiers assigned.

MEL will provide case narratives to the project manager, describing the quality of the data. Case narratives should include any problems encountered with the analyses, corrective actions taken, changes to the referenced method, and an explanation of data qualifiers. Narratives will also address the condition of samples on receipt, sample preparation, methods of analysis, instrument calibration, and results of QC tests.

Data Quality (Usability) Assessment

The project manager will assess the quality of the data, based on case narratives and data packages, to determine whether MQOs were met for this study. The project manager will determine whether the data should be accepted, accepted with additional qualification, or rejected and re-analysis considered.

Presence/absence results for TBB and TBPH will be considered usable for the study purpose unless the research center reports an issue with the data quality. Any correspondence regarding data quality will be evaluated by the project manager for determination of data usability.

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USGS, 2014. Mineral Commodity Profiles: Antimony. U.S. Department of the Interior, U.S. Geological Survey, Open File Report 03-019.

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van Bergen, S. and A. Stone, 2014. Flame Retardants in General Consumer and Children's Products. Washington State Department of Ecology, Olympia, WA. Publication No. 14-04-021.

Appendices

Appendix A. Data Gap Compilation Table

Flame Retardant (FR)	FR Acronym	Ecology children's non-furniture products data (n)	Ecology children's furniture data (n)	Ecology adult furniture data (n)	Reported in dust (# of studies >50% Det. Freq.)	Lab methods avail.?	Relevant Use to This Study
2,2-bis(chloromethyl)-propane-1,3-diyltetrakis(2-chloroethyl)bisphosphate	V6	17	11	1	1	Yes	Furniture
2-ethylhexyl-2,3,4,5-tetrabromobenzoate	TBB				8	+/-	Furniture
bis(2-ethylhexyl)-2,3,4,5-tetrabromophthalate	TBPH				7	+/-	Furniture
hexabromocyclododecane	HBCD	17	11	1	7	Yes	Furniture
triphenyl phosphate	TPP	42	22	2	3	Yes	Furniture
tris(1,3,-dichloro-2-propyl) phosphate	TDCPP	42	22	2	5	Yes	Furniture
tris(1-chloro-2-propyl) phosphate	TCPP	42	22	2	4	Yes	Furniture
tris(2-chloroethyl) phosphate	TCEP	42	22	2	6	Yes	Furniture
resorcinol-bis(diphenylphosphate)	RDP				1	No	Furniture and electronics
Antimony trioxide	ATO				0	Yes	Furniture and electronics
1,2-bis(2,4,6-tribromophenoxy)ethane	BTBPE				5	No	Electronics
bisphenol A bis(diphenyl phosphate)	BAPP				1	No	Electronics
decabromodiphenyl ethane	DBDPE	42	22	2	4	Yes	Electronics
Dechlorane Plus; Bis(hexachlorocyclopentadieno) Cyclooctane	DP				2	No	Electronics
tetrabromobisphenol-A	TBBPA	17	11	1	3	Yes	Electronics

	= Data gap
	= Well-documented in indoor dust studies

(n) = number of samples analyzed by 2012/2013 Ecology study (van Bergen and Stone, 2014). +/- = qualitative analysis available. * References listed on the following page.

Literature reviewed for flame retardants in indoor dust. *(See green column in previous table.)*

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Appendix B. Glossary, Acronyms and Abbreviations

Glossary

Halogenated: Containing a halogen, specifically bromine or chlorine.

Acronyms and Abbreviations

Ecology	Washington State Department of Ecology
MEL	Manchester Environmental Laboratory
MQO	Measurement quality objective
MRL	Method Reporting Limit
QA	Quality assurance
QC	Quality Control
SOP	Standard operating procedures
TBB	2-ethylhexyl-2,3,4,5-tetrabromobenzoate
TBPH	bis(2-ethylhexyl)-2,3,4,5-tetrabromophthalate
TCEP	tris(2-chloroethyl) phosphate
TCPP	tris(1-chloro-2-propyl) phosphate
TDCPP	tris(1,3-dichloro-2-propyl) phosphate
TPP	triphenyl phosphate

Units of Measurement

ppm	parts per million
mg/kg	milligram per kilogram