Flame Retardants in Electric and Electronic Casings, 2021

Environmental Assessment Program
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Abstract

In 2021, the Washington State Department of Ecology (Ecology) conducted a study to assess the presence of nine flame retardants in the plastic casings of electric and electronic equipment. Flame retardants prioritized included those identified in the Safer Products for Washington program [Revised Code of Washington (RCW) 70.350], are listed as Chemicals of High Concern to Children (CHCC) [Chapter 173-334 Washington Administrative Code (WAC)], or are included in the Children's Safe Products Act (CSPA) [Chapter 70A.430 RCW].

The nine flame-retardant chemicals prioritized in this study are:

- 1,2-bis(2,3,4,5,6-pentabromophenyl)ethane (DBDPE)
- 1,2-bis(2,4,6-tribromophenoxy)ethane (BTBPE)
- hexabromocyclododecane (HBCD)
- tetrabromobisphenol-A (TBBPA)
- 2,4,6-tris(2,4,6-tribromophenoxy)-1,3,5-triazine (TTBP-TAZ)
- decabromodiphenyl ether (BDE-209)
- 2,4,6-tribromophenol (2,4,6-TBP)
- resorcinol bis(diphenyl phosphate) (RDP)
- triphenyl phosphate (TPP)

During three months in early 2021, Ecology collected 151 products. These represented a wide range of residential and office electric and electronic products. A total of 80 component samples from 61 of the 151 electric and electronic products purchased were screened by x-ray fluorescence (XRF), prioritized for lab testing, and submitted for lab analysis of the nine targeted flame-retardant chemicals.

Of the 40 component samples tested for non-halogenated (organophosphate) flame retardants by Ecology's Manchester Environmental Laboratory (MEL), four contained both TPP and RDP at concentrations greater than 0.5%. These results are considered acceptable as qualified by MEL.

The subset of a second laboratory tested 40 component samples for the presence of DBDPE, BTBPE, HBCD, TBBPA, TTBP-TAZ, BDE-209, and 2,4,6-TBP. Results from this set were deemed inconclusive due to not meeting quality objectives in the Quality Assurance Project Plan (QAPP; Nelson 2021). All results were rejected as unusable for all purposes.

Publication information

This report is available on the Department of Ecology's website at:
https://apps.ecology.wa.gov/publications/SummaryPages/2303015.html.

Data for this study will be available on Ecology's Product Testing Database (PTDB) website at http://ecyapeem/ptdbpublicreporting.
Search Study: Flame Retardants in Electric and Electronic Casings – 2021.

The Activity Tracker Code for this study is 21-012.

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Quality Assurance Project Plan for this study:
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Background

Flame retardants, including organohalogen flame retardants, are a group of chemicals made up of several classes of chemicals, each with diverse chemical and physical properties. These properties influence their effectiveness and use in consumer products. Manufacturers add flame retardants to meet flammability standards. Many products, including electronics, upholstered furniture, and some children's products, contain a variety of intentionally added flame retardants.

In 2019, the Washington State Legislature passed The Safer Products for Washington Act (Chapter 70A.350 RCW, formerly Chapter 70.365 RCW, referenced as SPWA), which identified five priority chemical classes. The first set of priority chemical classes identified by the law included organohalogen flame retardants and organophosphate flame retardants. In July 2020, electric and electronic equipment (plastic device casings) were identified as priority consumer products that are considered a significant source of or use of priority chemicals (including organohalogen flame retardants, from now on referred to as halogenated flame retardants and organophosphate flame retardants) (Ecology 2020).

Among the priority chemical classes identified in the law were halogenated flame retardants, two alternative non-halogenated flame retardants, and several flame retardants have also been identified as Chemicals of High Concern to Children (CHCC) as part of the Children's Safe Products Act (CSPA). Five halogenated flame-retardant chemicals (TBBPA, HBCD, BDE-209, TCEP, and TDCPP) have a restriction limit of 1,000 ppm in certain children's products and residential upholstered furniture, as outlined in CSPA.

In 2021, Ecology assessed a broad range of electric and electronic products for the presence of select halogenated and organophosphate flame-retardant chemicals in the plastic device casings. Ecology acquired 151 typical home and office electronic products to meet the study's outlined goals and objectives.

- Screen at least one component for bromine, chlorine, antimony, and phosphorus using the X-ray fluorescence (XRF) analyzer to aid in prioritizing samples for laboratory analysis. XRF screening was used for prioritization, but comparisons beyond prioritizations were beyond the scope of Ecology's SOP PTP003.
- Record manufacture dates, Flame Retardant Chemical codes, UL 94 ratings, and any other plastic codes as comments in Ecology's Product Testing Database (PTDB). When possible, upload photos showing product UL 94 or other UL ratings into the PTDB.
- Submit 40 component samples to the laboratory for analysis of select organophosphate flame-retardant chemicals. Submit an additional 40 component samples for analysis of select halogenated flame-retardant chemicals.
- Concrete identification and prioritization of plastic resins by FTIR was beyond the scope of Ecology's SOP PTP005. The Product Testing (PT) library was not validated to make comparisons.

Methods

The quality assurance project plan (QAPP) for this study is Quality Assurance Project Plan: Flame Retardants in Electric and Electronic Casings (Nelson 2021).

Product Collection and Processing Samples

During January through March of 2021, Ecology acquired 151 products from 22 retailers, which included 21 south Puget Sound retail stores (some retail stores visited multiple times) and three online retailers (some online retailers also had retail store purchases). 18 general categories of products collected that included computing (21% of products), home appliances like treadmills (19%), audiovisual/photography products (18%) such as digital cameras, and beauty/personal care/hygiene products (9%) such as hair dryers and curling irons representing four of the highest distribution categories were purchased. The 151 products were separated into 821 individual plastic components.

An illustrative example of an electronic product broken down into components is presented in Figure A1 in the Appendix. Components were prioritized for lab analysis by X-ray Fluorescence (XRF) screening results, manufacturer claims, and availability. A total of 80 component samples from 61 of the 151 products were sent for lab analysis, which represents 10% of the 821 components screened and 40% of the products acquired.

From the 61 products that had component samples sent to the laboratory for testing:

- Several products had multiple components that screened high for halogens. Out of these, 15 products had more than one component sample from each product sent for lab analysis because of high screening results, claims by manufacturers, or other reasons. For example, the gold middle casing near the handle and the white covering top of the curling rod were different component samples from the ceramic curling iron. While the plastic front panel and the remote covering were different component samples from a DVD player.
- Five products were tested for both organophosphate and halogenated flame-retardant (FR) chemicals. No component samples were sent for lab analysis for both halogenated and organophosphate flame retardants, as it was expected that if the products contained FRs, they would contain either organophosphate or halogenated FRs.
    - For example, the charging dock top panel component of a Roomba 675 Robot Vacuum had the plastic code >PC+ABS FR(40)<, a combination of polycarbonate (PC) and acrylonitrile-butadiene-styrene (ABS) plastic, and therefore sent for lab analysis of non-halogenated flame-retardant chemicals. While the side panel attached to the internal top and vacuum black bottom panel components from the same product with the plastic code >ABS FR-(17)<, acrylonitrile butadiene styrene was analyzed for brominated flame-retardant chemicals.
- Seven of the 80 component samples were designated as internal components (parts of an electronic product that are entirely enclosed within the casing). They were selected for halogenated flame-retardant chemicals analysis based on factors including XRF screening results, representative breadth of products, and scope of SPWA regulations.

Chain of custody (COC) was maintained throughout the product collection, sample processing, and transfer of samples to the laboratories for analysis with the following observations. All temperatures on arrival met QAPP requirements. The cooler received at the contract laboratory,

ALS Burlington, included COC paperwork with a missing signature from sample shipping staff at Ecology's Manchester Environmental Laboratory (MEL). The project manager confirmed with the shipping staff that the samples were shipped under COC on March 24 and received at ALS Burlington under COC on March 26 with no observations noted.

Complete laboratory results for this study can be downloaded from Ecology's Product Testing Database (PTDB) website[1]. Search Study: Flame Retardants in Electric and Electronic Casings – 2021.

Laboratory Procedures

Organophosphate flame-retardant chemicals

MEL cryomilled solid samples for both organophosphate and halogenated flame-retardant chemicals analysis.

MEL prepared 40 samples for organophosphate flame-retardant chemicals analysis using the microwave extraction technique following a modified EPA 3546 method. Two lab sample batches of extracts were analyzed using a modified EPA 8270E method for the gas chromatography/mass spectrometry identification and quantification of organophosphate flame-retardant chemicals.

Halogenated flame-retardant chemicals

On March 24, 2021, MEL shipped 40 cryomilled samples to ALS Burlington, Canada. ALS received the samples in good condition on March 26, 2021and tested them for halogenated flame-retardant chemicals in three lab sample batches following a laboratory-developed method. MEL prepared an additional written case narrative assessing the quality of the data, and the case narrative is available upon request.

Data Quality

Quality control (QC) requirements and measurement quality objectives (MQOs) are outlined in the QAPP (Nelson 2021). QC tests for each batch analyzed consisted of a method blank, laboratory control samples (LCS), matrix spikes/matrix spike duplicates, and a laboratory duplicate. The project manager for this study assessed the quality and usability of the data. Organophosphate flame retardants and all data from MEL (TPP and RDP) were deemed usable as qualified. All contract lab brominated flame-retardants data were rejected, as described below.

Organophosphate flame-retardant chemicals

Acceptance criteria were met for organophosphate flame-retardant chemicals analysis with the following exceptions:

- The triphenyl phosphate result in a component sample (BY-5-1-7) was qualified as an estimate, "J," due to the matrix spike duplicate (MSD) sample result exceeding the upper control limit (>150%).

[1] http://ecyapeem/ptdbpublicreporting. Search Study: Flame Retardants in Electric and Electronic Casings – 2021

- The continuing calibration verification result for RDP for one sequence exceeded the lower control limit, but results were not reported for that sequence.
- All RDP results were qualified as estimates, "J," because the analysis was performed before accreditation was effective (July 1, 2021) without an approved waiver.

Halogenated flame-retardant chemicals

All contract-lab detected brominated flame retardants, DBDPE, BTBPE, HBCD, TBBPA, TTBP-TAZ, BDE-209, and 2,4,6-TBP, were rejected due to serious deficiencies in the ability to analyze the sample, meet QC criteria, or other technical reasons. The presence or absence of the analytes could not be verified and were qualified as rejected with code "REJ."

The QAPP specified a Stage 3 data validation. ALS performed significant method development work before analyzing the samples, encountered sample matrix effects on QC criteria, and had to provide multiple revisions of data packages and EDDs due to errors or omissions. Due to this increased complexity, a Stage 4 data validation to EPA method 8270E was performed using manual review and verification of reported results. This review discovered quality issues such as:

- exceeding sample extract holding times listed in the QAPP.
- not spiking surrogate compound before sample extraction.
- laboratory control sample outliers.
- matrix spike outliers.
- injected internal standard or internal standard outliers.
- initial calibration linearity outliers.
- initial calibration back calculation outliers.
- continuing calibration verification outliers.
- target analyte concentration in continuing calibration verification.
- extracted internal standard compound recovery outliers.
- surrogate compound recovery outliers.

Results

Complete laboratory results for this study can be downloaded from Ecology's Product Testing Database (PTDB) website[2]. Search Study: Flame Retardants in Electric and Electronic Casings – 2021.

A total of 80 component samples were selected for analysis from 151 electric and electronic products.

- Forty were analyzed for two organophosphate flame-retardant analytes.
- Forty were analyzed for seven brominated flame-retardant analytes.

[2] http://ecyapeem/ptdbpublicreporting

The results are presented with the following observations:

- Eighty lab samples were analyzed, which represents 10% of the 821 components screened and 40% of the products acquired (61 of the 151 products acquired).

Organophosphate flame-retardant chemicals

Table 1 displays the summary statistics for laboratory results of target organophosphate flame-retardant chemicals detected in component samples of electric and electronic products. Of the 40 component samples tested, 31 samples had at least one organophosphate flame-retardant chemical above the laboratory reporting limit, and 13 samples (Figure 2a) had an organophosphate flame-retardant chemical above 1000 ppm.

Table 1. Summary Statistics of Detected Organophosphate Flame Retardant Chemicals in Electric and Electronic Products.

Analyte	Resorcinol bis(diphenyl phosphate) (RDP)	Triphenyl phosphate (TPP)
Number of samples (n)	40	40
n > RL	5	31
% > RL	13%	78%
Minimum (ppm)*	433	171
Maximum (ppm)*	93,600	8,540

RL = Laboratory reporting (quantitation) limit.
*Statistic includes only detected results.

Figure 1a-b shows the concentration of the two organophosphate flame retardants in component samples by Component ID for the 31 electric and electronic products with detected results. Component samples are separated by the concentration of the analytes: 1000 ppm or greater (Figure 1a) and less than 1000 ppm (Figure 1b). Appendix Table A1 lists the product component description for each Component ID.

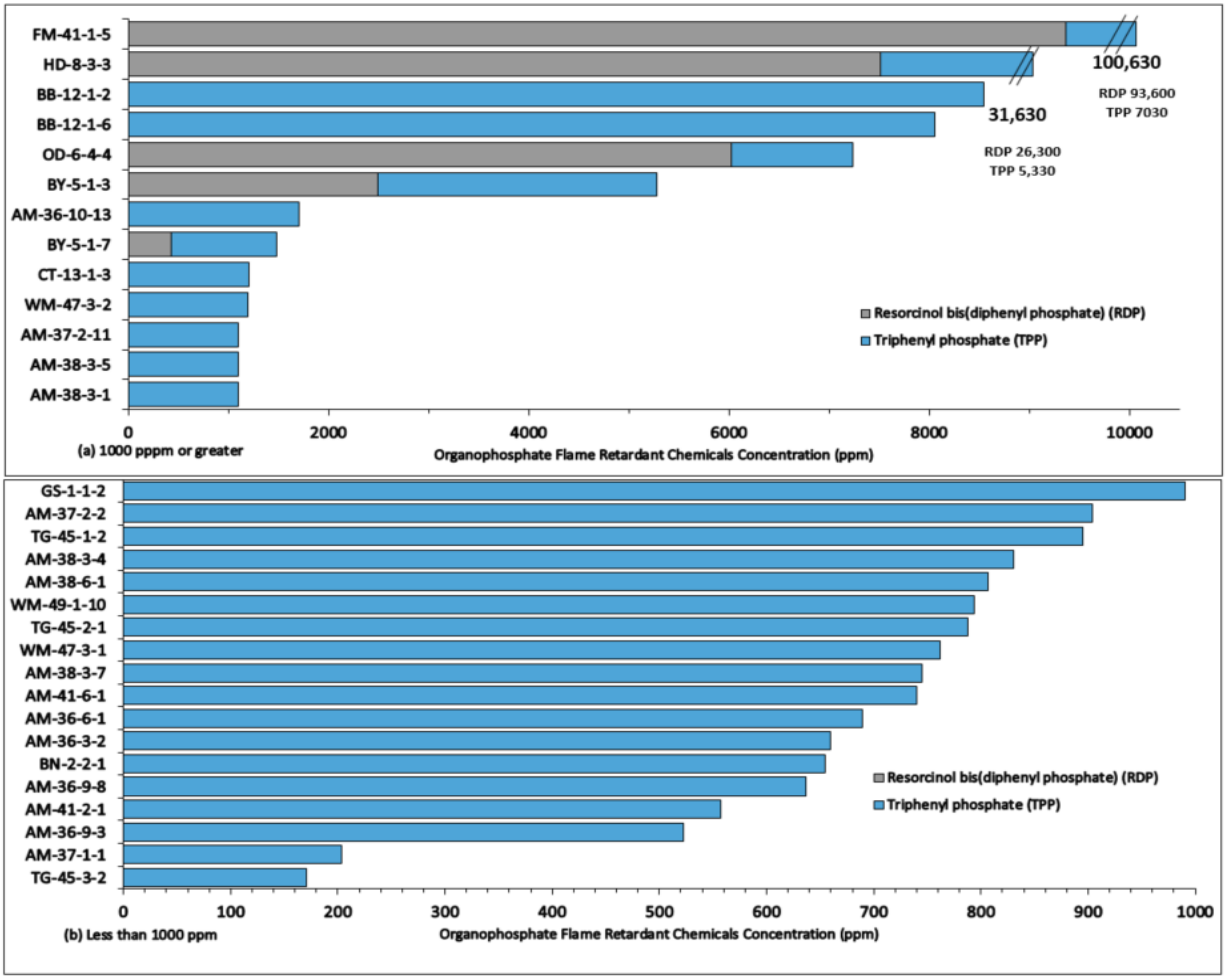

Figure 1a-b. Detected Organophosphate Flame-retardant Chemicals Concentrations in Electric and Electronic Products by Component ID in 2021: (a) 1000 ppm or greater, and (b) Less than 1000 ppm.

Appendix Table A1 lists the product component descriptions.

TPP was detected in 78% (31 of 40) component samples of electric and electronic products sent to the lab. TPP was detected above 1,000 ppm in 13 component samples. Of the 13 component samples with results above 1000 ppm, eight were from computing products, three were from home appliances, one was from electrical supplies, and one was from office machinery.

Four component samples had detected results above 5,000 ppm:

- The gray back casing of an air purifier (BB-12-1-2) at 8,540 ppm.
- The black back of a remote casing for an air purifier (BB-12-1-6) at 8,050 ppm.
- The power cord inlet housing cover for a printer (FM-41-1-5) at 7,030 ppm.
- The AC adapter of a power cord for a lava lamp (HD-8-3-3) at 5,330 ppm.

RDP was detected in nearly 13% (5 of 40) of component samples sent to the laboratory. Of the five component samples, three were from computing products, one was from electrical supplies, and one was from office machinery.

Three component samples had concentrations of RDP above 5,000 ppm:

- The power cord inlet housing cover for a printer (FM-41-1-5) at 93,600 ppm.
- The AC adapter of a power cord for a lava lamp (HD-8-3-3) at 26,300 ppm.
- The adapter casing for an electric stapler (OD-6-4-4) at 6,020 ppm.

Halogenated flame-retardant chemicals

Laboratory data for halogenated flame retardants were rejected due to data quality concerns. Lab data for brominated flame retardants was added to the product testing database for future reference, but with "REJ" qualifiers. The data should not be used for regulatory purposes.

Conclusions

Organophosphate flame retardants RDP and TPP were detected in several external electrical casing components from a variety of products collected in 2021. Concentrations of RDP and TPP varied between 0.02% and 9.3% and 0.15% to 0.7%, respectively. Categories of products with detectable RDP and/or TPP were computer components, video games, cameras, vacuums, and one hair styler. Due to laboratory data quality issues, halogenated flame retardants could not be determined in any products. Data for those compounds cannot be used to support the Safer Products for Washington program (implementation of Chapter 70A.350 RCW).

Reference

Nelson, K. 2021. Quality Assurance Project Plan – Flame Retardants in Electric and Electronic Casings. Publication 21-03-113. Washington State Department of Ecology. https://apps.ecology.wa.gov/publications/SummaryPages/2103113.

Appendix. Electric and Electronic Components

Electric and electronic products were deconstructed into individual components. Figure A1 shows an example of a lava lamp that was deconstructed for this study. This simple example succinctly illustrates the plastic casings for a typical product.

Picture Number	Product/ Component ID #	Product / Component Description	Comments
1	HD-8-3	Lava Lamp	Complete Product
2	HD-8-3-1	Lava Lamp - Gray Side Casing	An example of a layered/ co-mingled material.
3	HD-8-3-2	Lava Lamp - Black Bottom Panel	Product Label on based of Component
4	HD-8-3-3	Lava Lamp - AC Adapter Power Cord Casing	This component was selected for Lab Analysis Plastic Codes Polycarbonate (>PC<) Circled Above

Figure A1. Example of a lava lamp deconstructed for this study.

- The black bottom panel is readily identified as a component because an electrical unit is directly attached.
- The gray side is also identified as a plastic casing because it also houses electronics and is connected to the black bottom panel.
- The gray side casing component is noteworthy as there are two layers of plastic, the inner black side and outer gray side. If this component had been selected for lab analysis, it would have been sent as a comingled sample.
- The AC adapter power cord provides an example of a component with plastic code markings, one marking indicating it is a casing made of polycarbonate.

Table A1. Component IDs and Product Component Descriptions of the 31 electric and electronic products with detected results for TPP and RDP.

Component ID	Product Component Description	Analytical TPP Result (ppm)	Analytical RDP Result (ppm)
FM-41-1-5	Power cord inlet housing cover for a printer	7,030	96,300
AM-36-9-3	Oculus headset grey casing	522	
AM-36-9-8	Oculus hand control casing	637	
AM-41-2-1	Kindle e-Book - front black casing surrounding screen	557	
GS-1-1-2	Nintendo Switch Lite - yellow back	990	
BN-2-2-1	Glow Light reader tablet - front panel	655	
AM-38-6-1	HD Security System DVR - DVR top black covering	807	
TG-45-3-2	4K DVD player - front panel	171	
AM-37-1-1	Moto G stylus	249	
AM-36-3-2	PlayStation-shiny connection around console plugs	660	
AM-36-6-1	Smartwatch-pink covering on back of watch	689	
AM-38-3-5	X-box S series controller top panel	1100	
AM-38-3-4-2-8	X-Box console-bottom panel casing	830	
AM-38-3-1	X-box console casing	1100	
TG-45-1-2-	Cable modem-right side casing with lights	895	
WM-47-3-2	X-box blue wireless controller-back white casing	1190	
BY-5-1-3	Casing for a cable modem/Wi-Fi router	2,790	2,490
AM-41-6-1	Satellite receiver-top	740	
AM-37-2-2	X-box one-black bottom casing	904	
AM-38-3-7	X-box controller	745	
CT-12-7-4	One Step Volumizer - black casing on top		
AM-37-2-11	X-Box 1-white controller handle	1100	
CT-13-1-3	Portable drive-front cover	1200	
BB-12-1-2	Air purifier - gray back casing	8,540	
BB-12-1-6	Air purifier - black back of remote	8,050	

Component ID	Product Component Description	Analytical TPP Result (ppm)	Analytical RDP Result (ppm)
TG-45-2-1	Fire TV stick-top casing	788	
WM-47-31	X-box blue controller, top cover	762	
WM-49-1-10	Digital camera charger casing	794	
BY-5-1-7	Cable modem/Wi-fi router-base panel	1050	
HD-8-3-3	Lava lamp - AC adapter power cord	5,330	26,300
OD-6-4-4	Electric stapler - adapter casing	1,210	6,020
WM-49-1-10	Digital camera Power Shot SX420 IS - charger casing	794	
AM-36-10-13	Roomba 675 robot vacuum - charging dock top panel	1,700	

RL = Laboratory reporting (quantitation) limit. *Statistic includes only detected results.