



## **Survey of Presence and Breakdown of Brominated Flame Retardants (BFR's) in Vehicle Interior Components via Photodegradation**

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### **Abstract**

X-ray fluorescence spectroscopy has revealed widespread use of brominated flame-retardants (BFRs) such as decabromodiphenyl ether (BDE-209 or deca-BDE), in 14 different components of passenger car interiors from all major domestic and foreign manufacturers. By far the highest usage (in ca. 25 % of all models) of BFRs in vehicles is found in front seats from BFRs contained in the cover material or underlying foam. Although non-toxic alternatives are commercially available for all interior vehicle components, our study of over two hundred 2006/7 vehicle models using hand-held X-ray fluorescence spectrometers showed extensive use of BFRs in seating materials, door trim, arm rests and carpets.

Experiments using sealed quartz ampoules containing deca-BDE in nonane show complete photo-chemical degradation of deca-BDE after exposure to sunlight for 97.6 hours under environmental conditions representative of vehicle interiors. Degradation products analyzed include tetra, penta, hexa, hepta, octa, and some nona-BDEs. Bromine mass balances in terms of PBDEs found after exposure range between 37% for longest and 85 % for intermediate exposures, respectively. The unaccounted bromine in calculated mass balances indicate formation of so far unknown reaction products. Exposure of passengers to toxic degradation products of deca-BDE is an important health concern and the phase-out of BFR use in automobiles is recommended.

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### **Introduction**

After the recent ban of the toxic commercial products penta- BDE and octa-BDE, decabromodiphenylether (BDE-209 or deca-BDE) has become the most widely used additive commercial brominated flame retardant. Deca-BDE and other BFRs (brominated flame retardants) are primarily used in textiles, carpet backings, foams, and to a smaller extent in electronic circuit boards and plastics (1). As much as 250 grams of PBDEs are reportedly used in vehicles (1). Because of its widespread commercial usage, BDE-209 is now a major contaminant in the indoor and outdoor environment. PBDEs including BDE-209 are found in window films (2), sewage sludge (3), the human food chain (4, 5) and other biological media. High levels of deca-BDE have been reported in vehicle dust (6), and more recently in house dust (7, 8, 9), and dryer lint (10). Dust in particular may provide a major pathway for particle inhalation and ingestion, particularly for toddlers. Evaporative releases and emission rates of

deca and lower brominated congeners have been measured (11, 12) from an ABS television case at 23 °C suggesting that vapor inhalation may provide an additional pathway of absorption by mammals.

Decomposition of BDE-209 into more toxic lower brominated BDEs, dioxins, and furans is of high concern to public and environmental health. In her recent review, Stapleton (13) demonstrated multiple pathways for the degradation of deca-BDE in the environment including microbial, reductive, and photochemical mechanisms. The formation of toxic degradation products appears to be the primary reason for the proposal of a deca-BDE ban by some European countries, such as Norway, Sweden and Denmark (14). Most recently, the environment ministry of Norway has announced (26) an all-but-total ban on new products containing the brominated flame retardant deca-BDE in effect from 1 April/2008. However, the transportation sector enjoys the only exception to this ban. This is unfortunate since the outgassing of deca-BDE in sun-exposed vehicles is far higher than in furniture or electronics housed at ambient temperatures.

### **The Use and Fate of BFRs in Vehicles**

Since adults in the U.S. spend on average about 100 minutes per day in vehicles (29), an assessment of the chemical contents and environmental conditions of vehicle interiors is paramount to determining the risk of potential health effects and relevant exposure pathways. In an earlier study (1, 2) the authors reported the presence of BDE-209 and lower brominated BDEs in vehicle dust. However, windshield films showed no measureable levels of the deca congener. Because of the unique physical conditions of sun-exposed cars (temperature up to 70°C; UV radiation), photodegradation of BDE-209 and possibly other brominated flame-retardants (BFRs) was expected but not experimentally verified. Since the 2005 ban of commercial uses of penta- and octa-BDEs, it is assumed that these more toxic chemicals will be absent and replaced by BDE-209 or other BFRs in 2006/2007 car models. However, this assumption is questionable in light of a recent study (28) of 2006/07 models revealing high concentrations of tetra- and penta-BDEs in the air of these vehicles. While photodegradation of deca-BDE cannot be ruled out in this study, the ratios of BDE-47/BDE-99 closely resembled that of commercial penta-formulations in 50% of these new vehicles. Use of pre-ban stock of materials by suppliers may account for these findings.

In a preliminary survey we established the presence and extent of BFR usage by direct testing 14 interior vehicle components in over 200 new 2006/2007 models (15) using a non-destructive X-ray fluorescent technology (XRF). This analysis measures bromine content without specifying individual chemical structures (16). The use of non-destructive XRF analysis is now more widely preferred over costly and time-consuming analytical methods (22, 23). The reliability of the XRF (RoHS) method with homogenous materials has been studied (23) for several elements and shows satisfactory correlation with analytical methods for bromine and other elements. Data showing bromine contents of >1,000 ppm were considered as signifying the presence of BFRs, most likely BDE-209. The data presented in Table 1 reveal BFR uses in almost all components by some manufacturers but not by others. This clearly shows that flame protection without the use of BFRs is available for all vehicle components.

**Table 1: Use of BFRs in Interior Vehicle Components of 2006/2007 Models (15)**

Number of Components with Br contents > 1,000 ppm													
Manufacturer	BMW	Chrysler	Ford	GM	Honda	Hyundai	Mazda	Mitsubishi	Nissan	Subaru	Suzuki	Toyota	VW
# of Models tested	9	29	33	51	13	16	6	5	16	5	8	24	12
Arm rest/Console	0	1	0	3	2	3	0	1	1	0	0	1	0
Carpet	0	1	0	1	1	4	0	0	1	1	2	3	0
Door Trim (Hard)	0	0	1	0	0	0	0	0		0	0	0	0
Door Trim (Soft)	0	0	1	3	0	10	1	1	7	1	2	9	0
Ext.W.Seal	0	0	0	1	0	0	0	0	0	0	0	0	0
Front Seat-Front	0	7	2	12	1	9	3	1	2	4	2	11	0
Front Seat-Rear	0	1	6	3	2	4	3	1	0	2	3	4	0
Headliner	0	0	0	0	0	0	0	0	0	0	0	0	0
Instr. Panel	0	0	0	0	0	0	0	0	0	0	0	0	0
Sealer	0	0	0	0	0	0	0	0	0	0	0	0	0
Seat Base	0	1	0	0	1	0	0	0	0	0	0	0	0
Shift Knob	0	0	0	0	1	0	1	0	0	0	1	0	0
Steering Wheel	0	0	0	0	0	0	0	0	0	0	0	0	0
Wiring	0	3	3	3	0	3	0	0	0	0	0	0	1
Tot. BFR counts	0	14	13	26	8	33	8	4	11	8	10	28	1
% BFR counts	0	6.8	5.5	7.1	8.6	28.9	18.7	11.2	9.6	22.4	17.5	16.3	1.2

By far the highest usage (ca. 25 % of all models) of BFRs in vehicles is found in front seats from BFRs contained in the cover material or underlying foam as shown in Table 2. Since vehicle seats are covered with fabrics, vinyl, or leather, the XRF results obtained represent an average for a multilayer matrix measured to a depth of about 6 mm. Detailed analyses for bromine and chlorine of some car seats are shown in Table 2.

**Table 2: Examples of XRF Results with Multilayer Materials**

Model	Component	Cl	Br	Pb
1996 Dodge Neon	Cloth Seat	<LOD*	21,292	85
1996 Dodge Neon	Foam Only	41,247	86	<LOD
1996 Dodge Neon	Fabric Only Exterior	<LOD	62,383	217
1996 Dodge Neon	Fabric Only Interior	<LOD	77,385	324
1993 Mercury Grand Marque	PVC Seat	252,362	87	19
1993 Mercury Grand Marque	Foam Only	<LOD	8	<LOD
1993 Mercury Grand Marque	PVC Fabric only Exterior	438,171	192	<LOD
1993 Mercury Grand Marque	PVC Fabric Only Interior	<LOD	34	18
1998 Oldsmobile Silhouette	Leather Seat	<LOD	4,181	<LOD
1998 Oldsmobile Silhouette	Foam Only	<LOD	10,954	40
1998 Oldsmobile Silhouette	Leather Only Exterior	<LOD	2,780	<LOD
1998 Oldsmobile Silhouette	Leather Only Interior	<LOD	2,564	<LOD
1998 Oldsmobile Silhouette	PVC Seat Back	374,940	2,777	<LOD
1998 Oldsmobile Silhouette	Foam only	<LOD	523	<LOD
1998 Oldsmobile Silhouette	PVC Fabric Only Exterior	463,660	4,521	<LOD
1998 Oldsmobile Silhouette	PVC Fabric Only Interior	<LOD	2,245	<LOD
* Limit of detection				

## PBDE Exposure in Vehicles Prior to 2006

While our present focus is on vehicle models produced after the ban of commercial penta- and octa-BDEs, the danger of exposure to these toxic chemicals still persists with millions of vehicles currently in service. This is demonstrated by measurement of evaporative losses of BDEs from a seat foam sample of a 1998 model year vehicle (see highlighted columns in Table 3). Qualitative analysis (GC/MS) of the foam sample revealed the presence of tetra-, penta-, and hexa-BDEs but only traces of BDE-209 indicative of the composition of commercial penta-products. Foam samples were cut from the 1/2" mat into 2" x 3" peaces. Two peaces each were stacked to a height of about 1" and compressed to ca. 12 mm thickness while analyzed for bromine content with the XRF gun. The samples were then baked in a stove at 150-170°F and analyzed after 1 and 2 weeks of heat exposure. As shown in Table 3, substantial evaporative losses of bromine occurred after one week but much less after further heat exposure. Since commercial penta-BDE mixtures (Bromkal DE-71 and 70-5DE) contain 35 % tetra-BDE, the initial losses are likely due to evaporation of the lower boiling tetra-BDE. It must be noted that the source of the seat foam is a 1998 model implying previous evaporative losses during use of this vehicle.

**Table 3: Evaporative Loss of BDEs from Foam Samples at 150-170 F (ppm bromine)**

Sample Foam	Time 0		168 hrs			336 hrs		
	Br	Br +/- error	Br	Br +/- error	% Loss	Br	Br +/- error	% Loss
Sample 1	1,989.7	30.8	1,797.0	27.0	10%	1,845.0	27.0	7%
Sample 1	1,993.9	30.6	1,813.0	27.0	9%	1,829.0	27.0	8%
Sample 1	1,975.6	30.4	1,892.0	27.0	4%	1,832.0	27.0	7%
<b>Average</b>	<b>1,986.4</b>	<b>30.6</b>	<b>1,834.0</b>	<b>27.0</b>	<b>8%</b>	<b>1,835.3</b>	<b>27.0</b>	<b>8%</b>
Sample 2	2,179.1	33.9	2,024.0	30.0	7%	2,010.0	30.0	8%
Sample 2	2,157.8	33.4	2,030.0	30.0	6%	2,022.0	30.0	6%
Sample 2	2,176.0	34.1	2,056.0	31.0	6%	2,042.0	30.0	6%
<b>Average</b>	<b>2,171.0</b>	<b>33.8</b>	<b>2,036.7</b>	<b>30.3</b>	<b>6%</b>	<b>2,024.7</b>	<b>30.0</b>	<b>7%</b>
Sample 3	2,070.6	32.0	1,960.0		5%	1,892.0	28.0	9%
Sample 3	2,094.3	32.4	1,920.0	28.0	8%	1,855.0	28.0	11%
Sample 3	2,088.0	32.2	1,985.0	30.0	5%	1,886.0	28.0	10%
<b>Average</b>	<b>2,084.3</b>	<b>32.2</b>	<b>1,955.0</b>	<b>29.0</b>	<b>6%</b>	<b>1,877.7</b>	<b>28.0</b>	<b>10%</b>

## Previous Photo-chemical Degradation Studies of BDE-209

A major objective of this study was to observe the chemical stability of deca-BDE in an environment simulating the physico-chemical conditions behind car windshields exposed to solar radiation. Earlier, 'in vitro' investigations (17, 18, 19, 20, 24) confirming the photolysis of deca-BDE into lower brominated reaction products inclusive of polybrominated dioxins and furans, were primarily conducted in dilute solutions of water and various organic solvents and with direct, unfiltered UV exposure by sunlight or UV lamps. Half-lives in organic solvent media were in the range of minutes to hours but were up to several years in solid substrates. Stapleton et al (19) exposed deca-BDE adsorbed in house-dust to direct sunlight and estimated a half-life of 220 hours. In a more recent study (30) deca-BDE incorporated in high impact polystyrene degraded in sunlight with a half-life of 51 days.

Formation of polybrominated dibenzofurans (PBDFs) was clearly demonstrated in these experiments.

The fact that BDE-209 was found at high levels (ca. 10 ppm) in car dust (6) but not in windshield films suggests the operation of photolytic mechanisms. It is noteworthy to mention that oily windshield films related to the 'new car smell' contain a cocktail of volatile and semi-volatile organic chemicals (21). Acceleration of photolysis of deca-BDE contained in windshield films is expected at the high temperatures (ca. 70 °C) of car interiors exposed to full sunlight during summer weather conditions.

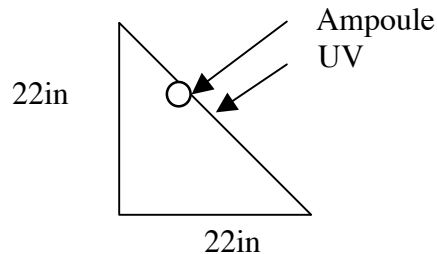
## Experimental

The primary objective of our study was to observe the effect of UV and visible light on decabromodiphenyl ether under physico-chemical conditions similar to those prevailing behind vehicle windshields exposed to the sun. Studies employing actual vehicles were ruled out due partially to unavailability - but more so - to the uncertainty of the nature of the chemical contents of the vehicles and to analytical complications.

In several preliminary photodegradation studies of deca we used teflon-stoppered quartz cuvettes in which films of pure BDE-209 (1 μg) or BDE-209 and tetracosane (10 μg and 50 μg respectively) were deposited. The cuvettes were placed behind the windshields of both mobile and stationary vehicles and exposed to sunlight and elevated temperatures (ca. 160 °F) for extended time periods (up to 20 hours of full sunlight). Exposed and control samples were extracted with hexane and subjected to GC/MS analysis using a DB-5 column, 30m x 0.25 mm ID, 0.25 μm film thickness in electron capture negative ionization mode. Chromatographic conditions are the same as published in (27). The exposed samples showed substantial losses of BDE-209 (70-80%) but no measurable quantities of lower brominated congeners. Presumably, photodegradation products and possibly deca-BDE itself evaporated at the elevated temperatures (ca. 160 °F) and escaped the teflon-stoppered cuvettes. This rendered the results of these experiments inconclusive. Sealed quartz ampoules were used in subsequent experiments to eliminate the possibility of evaporative losses. The ampoules were cooled (freezer) prior to opening for analysis.

Quartz tubing (OD=7 mm) was used to make ampoules of the following dimensions: ampoule length: 4 cm; rejuvenated neck: 2cm. The neck was drawn to an inner diameter large enough for insertion of a microsyringe needle. The ampoules were charged with 1 μg of BDE-209 in 20 μl of nonane from a standard (BDE-209-CS; Cambridge Isotope Laboratory) of 50 μg/ml of BDE-209 in nonane. The charged ampoules were stored upright on ice packs, and sealed within one hour. These ampoules were then stored in the dark under refrigeration (freezer) until exposure experiments commenced.

To closely duplicate exposure conditions in vehicles, a chamber was constructed (using 1/4 in posterboard) at a 45° angle to which a windshield<sup>1</sup> was attached using duct-tape. Base of the box is 22x22 in and height is 22 in.



Ampoules were mounted in pairs inside the box in a nearly horizontal position such that liquid movement into the narrow neck was avoided and exposure area kept at maximum. The deca dissolved in nonane formed liquid films or droplets depending on slight inclines of the mounted ampoules. This variation in sample distribution may explain a lack of reproducibility of our results but this shortcoming does not diminish the evidence for photodegradation and for the formation of lower brominated DEs by UV light filtered through a laminated glass windshield. It is usually assumed that laminated glass only transmits wavelengths > 320 nm. Measurements of total light energy ( $\mu\text{Watts}/\text{cm}^2$ ) transmitted through the windshield using the UV Light Meter (Lutron-UV-340; 290-390 nm range) was consistently 20-25% overall

A HOBO Temperature/Light Data Logger (Part # UA-002-XX) measuring degrees F and lumens/ $\text{cm}^2$  over a range of 150-1200 nm was also mounted inside the box. UV intensity inside and outside the chamber was occasionally measured with a Lutron UV 340 Light Meter (290-390 nm) measuring  $\mu\text{W}/\text{cm}^2$ . Typically, the following correlations between the HOBO and Lutron probes during full sunlight were obtained: HOBO outside, inside: 21,500 and 9,210 lumens/ $\text{cm}^2$ , respectively. Lutron UV 340 outside, inside: 6,100 and 1,350  $\mu\text{W}/\text{cm}^2$ , respectively.

To evaluate temperature effects, two ampoules and a HOBO Data Logger were mounted 2 in behind the windshield but outside the box. The individual exposure conditions

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<sup>1</sup> GM Laminated Glass GS  
DOT-376 AS1 M334  
Transm. 70% min  
AP Technoglass. 3

of the pairs of ampoules are indicated in Table 4 below. Total UV exposure hours (column 6) were extracted from the HOBO data logger ignoring cloudy conditions with exposures of < 3000 Lumens/ft<sup>2</sup>. Similarly, average temperatures indicate those at solar exposures of > 3000 Lumens/ft<sup>2</sup>.

**Table 4: Experimental Conditions of Deca-Photodegradation Study**

#	Experimental Conditions	Starting date of preparation	Exposure time of start	Exposure time ended	UV hrs	Average Lumens/ft <sup>2</sup> >3000	Average Temp. Degree F
1	Control; cold, dark	8/23-3pm	NA	NA	0	0	
2	Control; cold, dark	8/23-3pm	NA	NA	0	0	
3	Control; cold, dark	8/23-3pm	NA	NA	0	0	
4	Exposed outside box	8/23-3pm	8/28-3pm	9/21-9:30am	97.6	6227	122
5	Exposed outside box	8/23-3pm	8/28-3pm	9/21-9:30am	97.6	6227	122
6	Exposed inside box	8/23-3pm	8/28-3pm	9/01-10am	25.17	6318	157.8
7	Exposed inside box	8/23-3pm	8/28-3pm	9/01-10am	25.17	6318	157.8
8	Exposed inside box	8/23-3pm	8/28-3pm	9/05-10am	54.33	6027	154
9	Exposed inside box	8/23-3pm	8/28-3pm	9/05-10am	54.33	6027	154
10	Exposed inside box	8/23-3pm	8/28-3pm	9/11-12:30 pm	60	6024	155
11	Exposed inside box	8/23-3pm	8/28-3pm	9/11-12:30 pm	60	6024	155
12	Exposed inside box	8/23-3pm	8/28-3pm	9/17-5pm	85	6292	147
13	Exposed inside box	8/23-3pm	8/28-3pm	9/17-5pm	85	6292	147
14	Exposed inside box	8/23-3pm	8/28-3pm	9/21-9:30am	97.6	6227	146.9
15	Exposed inside box	8/23-3pm	8/28-3pm	9/21-9:30am	97.6	6227	146.9

After exposure, the ampoules were stored vertically in the freezer until analyzed. All ampoules were taken to the UM-SPH lab on 10/2/07. Tips of frozen ampoules were cut off and put into labeled vials. Via a micro syringe, 0.5 ml portions of hexane were added to ampoules and after 30 sec. of shaking transferred into the vials. This procedure was repeated once more resulting in 1.0 ml hexane extracts. After addition of 15  $\mu$ l of internal standard (PCB#30 and PCB#204), the samples were subjected to GC/MS analysis using a DB-5 column, 30m x 0.25 mm ID, 0.25um film thickness in electron capture negative ionization mode.

## Discussion of Results

Since higher chain-length hydrocarbons are typically present in vehicular environments including in windshield films, the presence of nonane was found acceptable since it was also the solvent used in commercially available deca-BDE standards. Hydrocarbons very likely act as suitable H-donors during photolysis.

The analytical results of our photodegradation study are presented in Table 5. As shown, measurable degradation of BDE-209 begins after 54, but more consistently, after 60 hours of exposure with concomitant formation of lower brominated congeners. This trend continues until the longest exposure period. Additional decomposition products (PBDEs 119, 174, 181, 204, 205) were determined for some selected samples after purchase of appropriate commercial standards. These data are highlighted in the Table 5. Since analysis of the additional congeners commenced after months of storage of hexane extracts, their values were corrected to be consistent with the earlier results. Nevertheless, these additional data are significant in showing the presence of other decomposition products.

Results for samples S4 and S5, representing exposure outside the box, but behind the windshield are consistent but surprising since both BDE-209 and nona-BDEs are absent. Mass balances of bromine calculated in terms of  $\Sigma$ PBDEs showed unaccounted losses of between 15 and 63% for intermediate and long-term exposures, respectively. This suggests formation of other non-analysed products including potentially brominated dioxins and furans as suggested by recent studies (20, 24, 25, 30).

Variations in our results (Table 5) are expected due to slight differences in the tilt angle of the ampoules that could change the UV-exposed surface area significantly. This lack of reproducibility does not allow for a determination of reaction rates or half-lives. However, this shortcoming does not diminish the evidence for photodegradation and for the formation of lower brominated PBDEs by UV light filtered through a laminated glass windshield. It is usually assumed that laminated glass only transmits wavelengths  $> 320$  nm. Measurements of total light energy ( $\mu$ Watts/cm<sup>2</sup>) transmitted through the windshield using the UV Light Meter (Lutron-UV-340; 290-390 nm range) was consistently 20-25% overall.

The evidence for photodegradation of BDE-209 into more toxic, lower brominated diphenyl ethers and possibly PBDD/Fs under conditions representative of vehicle interiors is of great public health concern. BDE-209 may be deposited on sticky windshields via dust particles or by condensation during cooling events and be subsequently photolysed upon solar exposure. Since the more toxic lower brominated congeners are more volatile, inhalation appears the dominant pathway for human absorption. As our results reveal, carmakers can avoid the use of BFRs by using commercially available non-toxic alternatives. Passengers are encouraged to vent cabin air as effectively as possible and avoid parking in areas highly exposed to solar radiation.

**Table 5: Analytical Results of BDE-209 Degradation Experiments in ng/ml**

Sample name	S1	S2	S3	S6	S7	S8	S9	S10	S11	S12	S14	S15	S4	S5
Full UV hrs	0	0	0	25.2	25.2	54.3	54.3	60	60	85	97.6	97.6	97.6	97.6
Ave. Lumens/ft2	0	0	0	6318	6318	6227	6227	6024	6224	6292	6227	6227	6227	6227
Ave.Temp. (°F)	freezer	freezer	freezer	158	158	154	154	155	155	147	147	147	122	122
Conditions	Ctr-1	Ctr-2	Ctr-3	inside	inside	inside	inside	inside	inside	inside	inside	inside	outside	outside
PBDE # 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PBDE # 28	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PBDE # 75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PBDE# 49	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PBDE #71	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PBDE#47	0	0	0	0	0	0	0	0	0	8.26	22.4	21.9	0	0
PBDE # 66	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PBDE#100	0	0	0	0	0	0	0	0	0	0	1	2.36	3.03	2.66
PBDE#99	0	0	0	0	0	7.85	8.68	1.53	2.15	22.42	31.8	35.2	7.78	5.14
PBDE # 85	0	0	0	0	0	4.77	3.08	1.33	2.89	0	12.5	14.5	0	0
PBDE # 119	NA	NA	NA	NA	NA	NA	NA	NA	0	0	11.4	18.35	0	0
PBDE # 154	0	0	0	0	0	0	0	0.82	2.28	3.01	2.49	3.78	8.1	8.06
PBDE#153	0	0	0	0	0	6.18	4.19	5.09	8.43	8.12	8.73	12.1	42.73	50.9
PBDE # 138	0	0	0	0	0	4.83	4.44	0.84	2.31	0	0	0	8.04	8.69
PBDE # 166	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PBDE # 174	NA	NA	NA	NA	NA	NA	NA	NA	0	0	0	0	12.48	14.71
PBDE # 183	0	0	0	0	0	0	0	0	0	0	0	0	9.92	11.47
PBDE # 190	0	0	0	0	0	7.95	11.6	17.8	21.5	8.48	14.8	17.5	33.97	27.18
PBDE # 181	NA	NA	NA	NA	NA	NA	NA	NA	6.44	7.23	7.38	8.13	0	0
PBDE # 204	NA	NA	NA	NA	NA	NA	NA	NA	9.45	10.16	11.34	9.57	0	0
PBDE # 205	NA	NA	NA	NA	NA	NA	NA	NA	5.34	4.3	17.36	18.65	0	0
PBDE#203	0	0	0	0	0	0	0	11.21	12.1	51.45	87.3	66	155.7	187.4
PBDE# 208	0	0	0	0	0	112.54	91.8	26.88	60	77.93	83.1	140	0	0
PBDE # 207	0	0	0	0	0	191.36	189	40.18	89	131.3	158	188	0	0
PBDE # 206	0	0	0	0	0	72.19	58.8	11.66	44.9	55.7	66.8	68.6	0	0
PBDE # 209	749	788.1	637.4	516.5	717	711.1	752	437.8	406	354.3	MLD	162.2	MLD	MLD

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