

## Sources of Exposure

## Toxicokinetics and Normal Human Levels

## Biomarkers/Environmental Levels

### General Populations

- The primary route of exposure for the general population is from ingestion of contaminated dust in indoor environments, including both personal residences and work-place environments.
- Exposure to PBDEs can also occur from eating foods with high fat content, such as fatty fish.
- People can also be exposed by inhalation; consumer products such as computer and electronic equipment (e.g., televisions) treated with PBDEs can continue to release these substances to air over time.
- Exposure can also occur by touching contaminated soil.
- Drinking water is not expected to be a major route of exposure to PBDEs.

### Occupational Populations

- Workers who were involved in the production and manufacture of PBDE-containing plastics and plastic products were exposed to higher concentrations of PBDEs than the general population.
- Occupational exposure to PBDEs also occurs in workers at plants that dismantle electronic equipment, computer monitor repair technicians, and automobile drivers, as well as other professions.

### Toxicokinetics

- PBDEs can enter the body from food, water, air, and soil.
- Breathing air that contains PBDEs or swallowing food, water, soil, or dust contaminated with PBDEs will result in more lower-brominated congeners than decaBDE being absorbed through the stomach or the lungs and entering the bloodstream.
- Animal studies indicate that lower-brominated PBDEs distribute widely in the body and preferentially to fat tissue.
- In the body, PBDEs are partially changed into breakdown products (metabolites).
- PBDEs and their metabolites can leave your body, mainly in the feces and a very small amount in urine. DecaBDE is eliminated faster than lower-brominated PBDEs.
- PBDEs can concentrate in breast milk fat and can enter the body of breastfed children. PBDEs can also reach the fetus through the placenta.

### Normal Human Levels

- National surveys of people from the U.S. general population conducted in 2003-2008 showed that the geometric mean serum levels of selected PBDE congeners ranged from approximately 4 ng/g to 21 ng/g (lipid basis).

### Biomarkers

- PBDEs in fat tissue, blood, and breast milk are indicators of general exposure for PBDEs.

### Environmental Levels

#### *Air*

- Levels of PBDEs in outdoor air in the United States are typically in the range 20–200 pg/m<sup>3</sup>.

#### *Sediment and Soil*

- Thirty-three surface soil measurements from 15 states in the United States had geometric mean concentration of PBDEs of 5.3 ng/g.

#### *Water*

- No data at the national level are available, but levels are expected to be low due the hydrophobic nature of PBDEs.

### Reference

ATSDR. 2017. Toxicological Profile for Polybrominated Diphenyl Ethers. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

# ToxGuide™ for Polybrominated Diphenyl Ethers (PBDEs)

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U.S. Department of Health and  
Human Services  
Public Health Service  
Agency for Toxic Substances  
and Disease Registry  
www.atsdr.cdc.gov

**Contact Information:**  
Division of Toxicology  
and Human Health Sciences  
Environmental Toxicology Branch

1600 Clifton Road NE, F-57  
Atlanta, GA 30329-4027  
1-800-CDC-INFO  
1-800-232-4636



## Chemical and Physical Information

## Routes of Exposure

## Relevance to Public Health (Health Effects)

### PBDEs are Mixtures

- PBDEs are mixtures of several brominated substances, each one of them is called a congener.
- There are 209 possible PBDE congeners. Congeners differ in the number and position of bromine atoms in the central molecule.
- There were three important commercial PBDE mixtures (i.e., penta-, octa-, and deca- bromodiphenyl ethers [BDEs]).
- DecaBDE's main use was for electronic enclosures, such as television cabinets. OctaBDE was largely used in plastics for business equipment. PentaBDE was principally used in foam for cushioning in upholstery.
- PentaBDE and octaBDE mixtures were voluntarily withdrawn from the U.S. marketplace by their manufacturers at the end of 2004. In the U.S., the manufacture and import of PBDEs was discontinued by the end of 2013.

- Inhalation – Minor route of exposure for people around older electronic equipment that can release PBDEs to the air. More important route of exposure for certain occupations.
- Oral – Principal route of exposure by ingestion of contaminated dust in personal residences and workplace.
- Dermal – Possible route of exposure by touching contaminated soil.

### PBDEs in the Environment

- PBDEs can be released into the air, water, and soil at places where they are produced or used.
- In air, PBDEs can be present in both the vapor phase and as particles; eventually PBDEs settle to soil or water.
- Sunlight can degrade some PBDEs.
- PBDEs do not dissolve easily in water, but stick to particles and settle to the bottom of river or lakes.
- Various food items, including fish, meat, and dairy products, have been shown to contain low concentrations of PBDEs.
- Lower-brominated PBDEs bio-concentrate in aquatic organisms.

Health effects are determined by the dose (how much), the duration (how long), and the route of exposure.

### Minimal Risk Levels (MRLs)

#### Inhalation

- No MRL was derived for acute-duration inhalation exposure ( $\leq 14$  days) to PBDEs
- An MRL of 0.006 mg/m<sup>3</sup> was derived for intermediate-duration inhalation exposure (15–364 days) to lower-brominated PBDEs.
- No MRL was derived for chronic-duration inhalation exposure (365 days or longer) to PBDEs.

#### Oral

- An MRL of 0.00006 mg/kg/day was derived for acute-duration oral exposure ( $\leq 14$  days) to lower-brominated PBDEs.
- An MRL of 0.01 mg/kg/day was derived for acute-duration oral exposure ( $\leq 14$  days) to decaBDE.
- An MRL of 0.000003 mg/kg/day was derived for intermediate-duration oral exposure (15–365 days) to lower-brominated BDEs.
- An MRL of 0.0002 mg/kg/day was derived for intermediate-duration oral exposure (15–365 days) to decaBDE.
- No MRL was derived for chronic-duration oral exposure (365 days or longer) to PBDEs.

### Health Effects

- There is no definite information on health effects of PBDEs in adults.
- The International Agency for Research on Cancer (IARC) has stated that PBDE as a group is *not classifiable as to its carcinogenicity to humans* based on inadequate evidence of carcinogenicity in humans and inadequate or limited evidence in experimental animals. The EPA states that mono-, di-, tri-, tetra-, penta-, hexa-, octa-, and nonaBDEs are *not classifiable as to human carcinogenicity* and that there is “*inadequate information*” to classify the specific congeners 2,2',4,4'-tetraBDE, 2,2',4,4',5-pentaBDE, and 2,2',4,4',5,5'-hexaBDE. However, EPA assigns a classification of “*suggestive evidence of carcinogenic potential*” for decaBDE. The Department of Health and Human Services has not classified PBDEs as carcinogens.

### Children's Health

- Results from human studies are suggestive of an effect of PBDEs on neurodevelopment in children, including impaired cognitive development (comprehension, memory), impaired motor skills, increased impulsivity, and decreased attention.
- PBDEs in maternal blood can pass through the placenta and reach the fetus. PBDEs in maternal milk fat can be transferred to nursing babies.
- Total PBDE intakes for children residing in the United States were estimated as 47.2 ng/kg body weight/day for 1–5 year olds, 13.0 ng/kg body weight/day for 6–11 year olds, and 8.3 ng/kg body weight/day for 12–19 year olds.