

An Alternatives Assessment for the Flame Retardant Decabromodiphenyl Ether (DecaBDE)

Chapter 4

Hazard Evaluation of DecaBDE and Alternatives



FINAL REPORT

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4 Hazard Evaluation of DecaBDE and Alternatives

This chapter summarizes the toxicological and environmental hazards of decabromodiphenyl ether (decaBDE) and each alternative chemical that was identified as a potential functional substitute for decaBDE. Evaluations of chemical formulations may also include associated substances (e.g., starting materials, byproducts, and impurities) if their presence is specifically required to allow that alternative to fully function in the assigned role. Otherwise, pure substances were analyzed in this assessment. Users of the alternative assessments should be aware of the purity of the trade product they purchase, as the presence of impurities may alter the assessment of the alternative. This report is a hazard assessment, not a risk assessment. Hazard assessment as a risk management tool is discussed in more detail in Section 1.4.

Toxicological and environmental endpoints included in the hazard profiles are discussed in Section 4.1 along with the criteria used to evaluate each hazard endpoint. Data sources and the review methodology are described in Section 4.2. The report then offers a detailed description of the utility of physical-chemical properties in understanding hazard in Section 4.3 and the process of evaluating human health and environmental endpoints in Sections 4.4 and 4.5, respectively. A discussion of the evaluation of endocrine activity is included in Section 4.6. The characteristics of each chemical included in the alternatives assessment are summarized in the comparative hazard summary table in Section 4.7. Lastly, the collected data and hazard profile of each chemical are presented in Section 4.8.

4.1 Toxicological and Environmental Endpoints

The assessment of endpoints with the intent to create hazard profiles for a Design for the Environment (DfE) alternatives assessment follows the guidance of the “Alternatives Assessment Criteria for Hazard Evaluation” (U.S. EPA 2011b). The definitions for each endpoint evaluated following these criteria are outlined in Section 4.1.1 and the criteria by which these endpoints are evaluated are outlined in Section 4.1.2. Lastly, there are endpoints which DfE characterizes but does not assign criteria to and these are summarized in Section 4.1.3.

4.1.1 Definitions of Each Endpoint Evaluated Against Criteria

Hazard designations for each chemical discussed in this report were made by direct comparison of the experimental or estimated data to the DfE “*Alternatives Assessment Criteria for Hazard Evaluation*” (U.S. EPA 2011b). Table 4-1 provides brief definitions of human health toxicity, environmental toxicity and environmental fate endpoints.

Table 4-1: Definitions of Toxicological and Environmental Endpoints for Hazard Assessment

Endpoint Category	Endpoint	Definition
Human Health Effects	Acute Mammalian Toxicity	Adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours.

Endpoint Category	Endpoint	Definition
	Carcinogenicity	Capability of a substance to increase the incidence of malignant neoplasms, reduce their latency, or increase their severity or multiplicity.
	Mutagenicity/Genotoxicity	<i>Mutagenicity</i> - The ability of an agent to induce permanent, transmissible changes in the amount, chemical properties or structure of the genetic material. These changes may involve a single gene or gene segment, a block of genes, parts of chromosomes, or whole chromosomes. Mutagenicity differs from genotoxicity in that the change in the former case is transmissible to subsequent cell generations. <i>Genotoxicity</i> – The ability of an agent or process to alter the structure, information content, or segregation of DNA, including those which cause DNA damage by interfering with normal replication process, or which in a non-physiological manner (temporarily) alter its replication.
	Reproductive Toxicity	The occurrence of biologically adverse effects on the reproductive systems of females or males that may result from exposure to environmental agents. The toxicity may be expressed as alterations to the female or male reproductive organs, the related endocrine system, or pregnancy outcomes. The manifestation of such toxicity may include, but is not limited to: adverse effects on onset of puberty, gamete production and transport, reproductive cycle normality, sexual behavior, fertility, gestation, parturition, lactation, developmental toxicity, premature reproductive senescence or modifications in other functions that were dependent on the integrity of the reproductive systems.
	Developmental Toxicity	Adverse effects in the developing organism that may result from exposure prior to conception (either parent), during prenatal development, or postnatally to the time of sexual maturation. Adverse developmental effects may be detected at any point in the lifespan of the organism. The major manifestations of developmental toxicity include: (1) death of the developing organism, (2) structural abnormality, (3) altered growth, and (4) functional deficiency.
	Neurotoxicity	An adverse change in the structure or function of the central and/or peripheral nervous system following exposure to a chemical, physical or biological agent.

Endpoint Category	Endpoint	Definition
	Repeated Dose Toxicity	Adverse effects (immediate or delayed) that impair normal physiological function (reversible and irreversible) of specific target organs or biological systems following repeated exposure to a chemical substance by any route relevant to humans. Adverse effects include biologically significant changes in body and organ weights, changes that affect the function or morphology of tissues and organs (gross and microscopic), mortality, and changes in biochemistry, urinalysis, and hematology parameters that are relevant for human health; may also include immunological and neurological effects.
	Respiratory Sensitization	Hypersensitivity of the airways following inhalation of a substance.
	Skin Sensitization	A cell-mediated or antibody-mediated allergic response characterized by the presence of inflammation that may result in cell death, following an initial induction exposure to the same chemical substance, i.e., skin allergy.
	Eye Irritation/Corrosivity	Irritation or corrosion to the eye following the application of a test substance.
	Skin Irritation/Corrosion	Skin irritation- reversible damage to the skin following the application of a test substance for up to 4 hours. Skin corrosion- irreversible damage to the skin namely, visible necrosis through the epidermis and into the dermis following the application of a test substance for up to 4 hours.
Environmental Toxicity	Environmental toxicity refers to adverse effects observed in living organisms that typically inhabit the wild; the assessment is focused on effects in three groups of surrogate aquatic organisms (freshwater fish, invertebrates, and algae).	
	Aquatic Toxicity (Acute)	The property of a substance to be injurious to an organism in a short-term, aquatic exposure to that substance.
	Aquatic Toxicity (Chronic)	The property of a substance to cause adverse effects to aquatic organisms during aquatic exposures which were determined in relation to the life-cycle of the organism.
Environmental Fate	Environmental Persistence	The length of time the chemical exists in the environment, expressed as a half-life, before it is destroyed (i.e., transformed) by natural or chemical processes. For alternative assessments, the amount of time for complete assimilation (ultimate removal) is preferred over the initial step in the transformation (primary removal).
	Bioaccumulation	The process in which a chemical substance is absorbed in an organism by all routes of exposure as occurs in the natural environment, e.g., dietary and ambient environment sources. Bioaccumulation is the net result of competing processes of chemical uptake into the organism at the respiratory surface and from the diet and chemical elimination from the organism including respiratory exchange, fecal egestion, metabolic biotransformation of the parent compound and growth dilution.

The hazard profile for each chemical contains endpoint specific summary statements (see Section 4.8). For each of the endpoints listed in Table 4-1, these summary statements provide the hazard designation, the type of data (experimental or estimated) and the rationale. The endpoint summaries may also include explanatory comments, a discussion of confounding factors or an indication of the confidence in the data to help put the results in perspective.

4.1.2 Criteria

Table 4-2 summarizes the criteria that were used by the U.S. Environmental Protection Agency (EPA) DfE Program to interpret the data presented in the hazard evaluations. The *DfE Alternatives Assessment Criteria for Hazard Evaluation* underwent internal and public comment, and were finalized in 2011 (U.S. EPA 2011b). A hazard designation for each human health endpoint was not given for each route of exposure but rather was based on the exposure route with the highest hazard designation. Data may have been available for some or all relevant routes of exposure.

The details as to how each endpoint was evaluated are described below and in the DfE full criteria document, *DfE Alternatives Assessment Criteria for Hazard Evaluation*, available at: http://www.epa.gov/dfe/alternatives_assessment_criteria_for_hazard_eval.pdf.

Table 4-2: Criteria Used to Assign Hazard Designations

Endpoint	Very High	High	Moderate	Low	Very Low
Human Health Effects					
Acute mammalian toxicity					
Oral median lethal dose (LD ₅₀) (mg/kg)	≤50	>50–300	>300–2000	>2000	–
Dermal LD ₅₀ (mg/kg)	≤200	>200–1000	>1000–2000	>2000	–
Inhalation median lethal concentration (LC ₅₀) - vapor/gas (mg/L)	≤2	>2–10	>10–20	>20	–
Inhalation LC ₅₀ - dust/mist/fume (mg/L)	≤0.5	>0.5–1.0	>1–5	>5	–
Carcinogenicity					
Carcinogenicity	Known or presumed human carcinogen (equivalent to Globally Harmonized System of Classification and Labeling of Chemicals (GHS) Categories 1A and 1B)	Suspected human carcinogen (equivalent to GHS Category 2)	Limited or marginal evidence of carcinogenicity in animals (And inadequate evidence in humans)	Negative studies or robust mechanism-based Structure Activity Relationship (SAR) (As described above)	–

Endpoint	Very High	High	Moderate	Low	Very Low
Mutagenicity/Genotoxicity					
Germ cell mutagenicity	GHS Category 1A or 1B: Substances known to induce heritable mutations or to be regarded as if they induce heritable mutations in the germ cells of humans	GHS Category 2: Substances which cause concern for humans owing to the possibility that they may induce heritable mutations in the germ cells of humans OR	Evidence of mutagenicity supported by positive results in <i>in vitro</i> OR <i>in vivo</i> somatic cells of humans or animals	Negative for chromosomal aberrations and gene mutations, or no structural alerts.	--
Mutagenicity and genotoxicity in somatic cells		Evidence of mutagenicity supported by positive results in <i>in vitro</i> AND <i>in vivo</i> somatic cells and/or germ cells of humans or animals			
Reproductive toxicity					
Oral (mg/kg/day)	–	<50	50–250	>250-1000	>1000
Dermal (mg/kg/day)	–	<100	100–500	>500-2000	>2000
Inhalation - vapor, gas (mg/L/day)	–	<1	1–2.5	>2.5-20	>20
Inhalation - dust/mist/fume (mg/L/day)	–	<0.1	0.1–0.5	>0.5-5	>5
Developmental toxicity					
Oral (mg/kg/day)	–	<50	50–250	>250-1000	>1000
Dermal (mg/kg/day)	–	<100	100–500	>500-2000	>2000
Inhalation - vapor, gas (mg/L/day)	–	<1	1–2.5	>2.5-20	>20
Inhalation - dust/mist/fume (mg/L/day)	–	<0.1	0.1–0.5	>0.5-5	>5
Neurotoxicity					
Oral (mg/kg/day)	–	<10	10–100	>100	–
Dermal (mg/kg/day)	–	<20	20–200	>200	–
Inhalation - vapor, gas (mg/L/day)	–	<0.2	0.2–1.0	>1.0	–
Inhalation - dust/mist/fume (mg/L/day)	–	<0.02	0.02–0.2	>0.2	–
Repeated-dose toxicity					
Oral (mg/kg/day)	–	<10	10–100	>100	–

Endpoint	Very High	High	Moderate	Low	Very Low
Dermal (mg/kg/day)	–	<20	20–200	>200	–
Inhalation - vapor, gas (mg/L/day)	–	<0.2	0.2–1.0	>1.0	–
Inhalation - dust/mist/fume (mg/L/day)	–	<0.02	0.02–0.2	>0.2	–
Sensitization					
Skin sensitization	–	High frequency of sensitization in humans and/or high potency in animals (GHS Category 1A)	Low to moderate frequency of sensitization in human and/or low to moderate potency in animals (GHS Category 1B)	Adequate data available and not GHS Category 1A or 1B	–
Respiratory sensitization	–	Occurrence in humans or evidence of sensitization in humans based on animal or other tests (equivalent to GHS Category 1A and 1B)	Limited evidence including the presence of structural alerts	Adequate data available indicating lack of respiratory sensitization	–
Irritation/corrosivity					
Eye irritation/corrosivity	Irritation persists for >21 days or corrosive	Clearing in 8–21 days, severely irritating	Clearing in ≤7 days, moderately irritating	Clearing in <24 hours, mildly irritating	Not irritating
Skin irritation/corrosivity	Corrosive	Severe irritation at 72 hours	Moderate irritation at 72 hours	Mild or slight irritation at 72 hours	Not irritating
Endocrine activity					
Endocrine Activity	For this endpoint, High/Moderate/Low etc. characterizations will not apply. A qualitative assessment of available data will be prepared.				
Environmental Toxicity and Fate					
Aquatic toxicity					
Acute aquatic toxicity – LC ₅₀ or half maximal effective concentration (EC ₅₀) (mg/L)	<1.0	1–10	>10–100	>100 or No Effects at Saturation (NES)	–
Chronic aquatic toxicity – lowest observed effect concentration (LOEC) or chronic value (ChV) (mg/L)	<0.1	0.1–1	>1–10	>10 or NES	–
Environmental persistence					

Endpoint	Very High	High	Moderate	Low	Very Low
Persistence in water, soil, or sediment	Half-life >180 days or recalcitrant	Half-life of 60–180 days	Half-life <60 but ≥16 days	Half-life <16 days OR passes Ready Biodegradability test not including the 10-day window. No degradation products of concern.	Passes Ready Biodegradability test with 10-day window. No degradation products of concern.
Persistence in air (half-life days)	For this endpoint, High/Moderate/Low etc. characterizations will not apply. A qualitative assessment of available data will be prepared.				
Bioaccumulation					
Bioconcentration Factor (BCF)/Bioaccumulation Factor (BAF)	>5000	5000–1000	<1000–100	<100	–
Log BCF/BAF	>3.7	3.7–3	<3-2	<2	–

Very High or Very Low designations (if an option for a given endpoint in Table 4-2) were assigned only when there were experimental data located for the chemical under evaluation. In addition, the experimental data must have been collected from a well conducted study specifically designed to evaluate the endpoint under review. If the endpoint was estimated using experimental data from a close structural analog, by professional judgment, or from a computerized model, then the next-level designation was assigned (e.g., use of data from a structural analog that would yield a designation of very high would result in a designation of high for the chemical in review). One exception is for the estimated persistence of polymers with an average molecular weight (MW) >1,000 daltons, which may result in a Very High designation.

4.1.3 Endpoints Characterized but Not Evaluated

Several additional endpoints were characterized, but not evaluated against hazard criteria. This is because the endpoints lacked a clear consensus concerning the evaluation criteria (endocrine activity), data and expert judgment were limited for industrial chemicals (persistence in air, terrestrial ecotoxicology), or the information was valuable for the interpretation of other toxicity and fate endpoints (including toxicokinetics and transport in the environment).

Table 4-3: Definitions of Endpoints and Information Characterized but Not Evaluated Against Hazard Criteria

Toxicological Endpoint	Definition
Toxicokinetics	The determination and quantification of the time course of absorption, distribution, biotransformation, and excretion of chemicals (sometimes referred to as <i>pharmacokinetics</i>).
Biomonitoring Information	The measured concentration of a chemical in biological tissues where the analysis samples were obtained from a natural or non-experimental setting.
Environmental Transport	The potential movement of a chemical, after it is released to the environment, within and between each of the environmental compartments, air, water, soil, and sediment. Presented as a qualitative summary in the alternative assessment based on physical-chemical properties, environmental fate parameters, and simple volatilization models. Also includes distribution in the environment as estimated from a fugacity model ¹ .
Persistence in Air	The half-life for destructive removal of a chemical substance in the atmosphere. The primary chemical reactions considered for atmospheric persistence include hydrolysis, direct photolysis, and the gas phase reaction with hydroxyl radicals, ozone, or nitrate radicals. Results are used as input into the environmental transport models.

Toxicological Endpoint	Definition
Immunotoxicology	Adverse effects on the normal structure or function of the immune system caused by chemical substances (e.g., gross and microscopic changes to immune system organs, suppression of immunological response, autoimmunity, hypersensitivity, inflammation, and disruption of immunological mechanistic pathways).
Terrestrial Ecotoxicology	Reported experimental values from guideline and nonguideline studies on adverse effects on the terrestrial environment. Studies on soil, plants, birds, mammals, invertebrates were also included.
Endocrine Activity	A change in endocrine homeostasis caused by a chemical or other stressor from human activities (e.g., application of pesticides, the discharge of industrial chemicals to air, land, or water, or the use of synthetic chemicals in consumer products.)

¹A fugacity model predicts partitioning of chemicals among air, soil, sediment, and water under steady state conditions for a default model “environment” (U.S. EPA 2011e).

4.2 Data Sources and Assessment Methodology

This section explains how data were collected (Section 4.2.1), prioritized and reviewed (Section 4.2.2) for use in the development of hazard profiles. High-quality experimental studies lead to a thorough understanding of behavior and effects of the chemical in the environment and in living organisms. Analog approaches and SAR-based estimation methods are also useful tools and are discussed throughout this section. Information on how polymers differ from discrete chemicals in terms of how they are evaluated is presented in Section 4.2.3.

4.2.1 Identifying and Reviewing Measured Data

For each chemical assessed, data were collected in a manner consistent with the *High Production Volume (HPV) Chemical Challenge Program Guidance* (U.S. EPA 1999b) on searching for existing chemical information. This process resulted in a comprehensive search of the literature for available experimental data. For chemicals well characterized by experimental studies this usually resulted in the collection of recent high-quality reviews or peer-reviewed risk assessments. These were supplemented by primary searches of scientific literature published after these secondary sources were released, this explained in greater detail below. For chemicals that are not as well characterized, that is, where these secondary sources were not available or lacked relevant or adequate data, a comprehensive search of the primary scientific literature was done. Subsequently, these searches led to the collection and review of articles from the scientific literature, industrial submissions, encyclopedic sources, and government reports. In addition, data presented in EPA public databases (e.g., integrated risk information system (IRIS); the High Production Volume Information System) and confidential databases were obtained for this project. Generally, foreign language (non-English) reports were not used unless they provided information that was not available from other sources.

Chemical assessments were performed by first searching for experimental data for all endpoints in Table 4-2. For most alternatives assessed, high quality secondary sources were not available; therefore a comprehensive search of the literature was performed to identify experimental data. In some cases, confidential studies submitted to EPA by chemical manufacturers were also available to support hazard designations. For those chemicals that were expected to form stable

metabolites, searches were performed to identify relevant fate and toxicity information for the metabolite or degradation product.

Well Studied Chemicals – Literature Search Strategy

As mentioned above, for chemicals that have been well characterized, the literature review focused primarily on the use of secondary sources, such as Agency for Toxic Substances and Disease Registry Toxicological Profiles or IRIS assessments. Using high-quality secondary sources maximized available resources and eliminated potential duplication of effort. However, more than one secondary source was typically used to verify reported values, which also reduced the potential for presenting a value that was transcribed incorrectly from the scientific literature. Although other sources might also contain the same experimental value for an endpoint, effort was not focused on building a comprehensive list of these references, as it would not have enhanced the ability to reach a conclusion in the assessment. When data for a selected endpoint could not be located in a secondary source for an otherwise well studied chemical, the primary literature was searched by endpoint and experimental studies were assessed for relevant information.

Making Predictions in the Absence of Measured Data

In the absence of primary or secondary data, hazard designations were based on (1) Quantitative Structure Activity Relationships (QSAR)-based estimations from the EPA New Chemical Program's predictive methods; (2) analog data; (3) class-based assignments from the EPA Chemical Categories document and (4) expert judgment by EPA subject matter experts.

For chemicals that lacked experimental information, QSAR assessments were made using either EPA's Estimation Program Interface (EPISuite™) for physical-chemical property and environmental fate endpoints or EPA's Ecological Structure Activity Relationships (ECOSAR™) QSARs for ecotoxicity. For the cancer endpoint, estimates were also obtained from EPA's OncoLogic expert system. These estimation methods have been automated, and are available for free (U.S. EPA 2012c). Often analog data were used to support predictions from models. These approaches were described in the EPA Pollution Prevention (P2) Framework and Sustainable Futures (SF) program (U.S. EPA 2005b; U.S. EPA 2011e).

For some physical-chemical properties that could not be estimated using EPISuite™, such as acid/base dissociation constants, other available methods (e.g., the Sparc Performs Automated Reasoning in Chemistry website for dissociation constants) were used. All estimation methods employed were limited to those freely available in the public domain.

The methodology and procedures used to assess polymers are described in Section 4.2.3. In addition, the endpoints for impurities or oligomers with a MW >1,000 daltons were estimated using professional judgment and the results assessed for inclusion in the overall hazard designation. This process is described, as appropriate, under the corresponding endpoints appearing in Section 4.3.

When QSAR models were not available, professional judgment was used to identify hazards for similar chemicals using the guidance from EPA's New Chemicals Categories (U.S. EPA 2010f). The categories identify substances that share chemical and toxicological properties and possess potential health or environmental concerns (U.S. EPA 2010a). In the absence of an identified category, analogs for which experimental data are available were identified using EPA's Analog Identification Methodology (AIM) or by substructure searches of confidential EPA databases (U.S. EPA 2012a). If a hazard designation was still not available, the expert judgment of scientists from EPA's New Chemical Program would provide an assessment of the physical-chemical properties, environmental fate, aquatic toxicity and human health endpoints to fill remaining data gaps.

4.2.2 Hierarchy of Data Adequacy

Once the studies were obtained, they were evaluated to establish whether the hazard data were of sufficient quality to meet the requirements of the assessment process. The adequacy and quality of the studies identified in the literature review are described in the Data Quality field of the chemical assessments presented in Section 4.8. The tiered approach described below represents a general preferred data hierarchy, but the evaluation of toxicological data also requires flexibility based on expert judgment.

1. One or more studies conducted in a manner consistent with established testing guidelines
2. Experimentally valid but nonguideline studies (i.e., do not follow established testing guidelines)
3. Reported data without supporting experimental details
4. Estimated data using SAR methods or professional judgment based on an analog approach
5. Expert judgment based on mechanistic and structural considerations

In general, data were considered adequate to characterize an endpoint if they were obtained using the techniques identified in the HPV data adequacy guidelines (U.S. EPA 1999b). Studies performed according to Harmonized EPA or Organisation for Economic Cooperation and Development guidelines were reviewed to confirm that the studies followed all required steps.

Experimental studies published in the open literature were reviewed for their scientific rigor and were also compared and contrasted to guideline studies to identify potential problems arising from differences in the experimental design. Data from adequate, well-performed, experimental studies were used to assign hazard designations in preference to those lacking in sufficient experimental detail. When multiple adequate studies were available for a given endpoint, any discrepancies that were identified within the set of data were examined further and addressed using a weight-of-evidence approach that was described in the data entry to characterize the endpoint whenever possible.

When available, experimental data from guideline or well-performed experimental studies were preferred (Items 1 and 2 in the hierarchy list). Information from secondary sources such as Material Safety Data Sheets, or online databases (such as the National Library of Medicine's Hazardous Substances Data Bank, Item 3 in the hierarchy list) was considered appropriate for

some endpoints when it included numerical values for effect levels that could be compared to the evaluation criteria.

4.2.3 Assessment of Polymers and Oligomers

The methodology and procedures used to assess polymers were slightly different than those used for oligomers, discrete compounds and simple mixtures. Although experimental data for polymers were identified using the literature search techniques discussed above in Section 4.2.1, in the absence of experimental data, estimates were performed using professional judgment as presented in the literature and the SF Polymer Assessment guidance (U.S. EPA 2010d). The polymers are a mixture of molecules with a distribution of components (e.g., different chain lengths) that depend on the monomers used, their molar ratios, the total number of monomeric units in the polymer chain, and the manufacturing conditions. To account for this variation, the average MW profile (also referred to as the number average molecular weight MW_n) was used in their assessment as the individual chains rarely have the same degree of polymerization and weight yet their physical, chemical, and environmental properties are essentially identical for the purposes of this assessment. The polymers evaluated as alternatives typically have average MWs ranging from >1,000 to <100,000 daltons.

For polymers with relatively low average MWs (i.e., those with average MWs generally less than 2,000), the alternative assessment also determined the amount of oligomers and unchanged monomers (starting materials) in the MW profile with MWs <1,000 daltons. Special attention was paid to materials that have a MW <1,000 daltons as these materials often have the highest hazard (potentially bioavailable substances) in the mixture. This type of assessment was similar to the evaluation of the hazards of impurities present in discrete chemical products. Methodological differences between the evaluation of discrete products and polymers are discussed in Section 4.3.

For the Alternatives Assessment, there were chemicals that are mixtures of low MW oligomers comprised of 2 or 3 repeating units. The hazard assessment evaluated all oligomers present. From all the oligomers, the higher concern material was used to assign the hazard designation. This process is essentially identical to the evaluation of the hazards associated with impurities or byproducts present in discrete chemical products. As a result, the alternatives assessment process determined the amount of oligomers and unchanged monomers (starting materials) present and considered their potential hazards in the alternatives designation.

4.3 Importance of Physical and Chemical Properties, Environmental Transport, and Biodegradation

Physical-chemical properties provide basic information on the characteristics of a chemical substance and were used throughout the alternatives assessment process. These endpoints provide information required to assess potential environmental release, exposure, and partitioning as well as insight into the potential for adverse toxicological effects. The physical-chemical properties are provided in the individual chemical hazard profiles presented in Section 4.8. For information on how key physical-chemical properties of alternatives can be used to address the potential for human and environmental exposure, please refer to Table 5-1.

Descriptions of relevant physical-chemical properties and how they contribute to the hazard assessments are presented below.

Molecular Weight (MW)

MW informs how a chemical behaves in a physical or biological system including bioavailability and environmental fate. In general, but not strictly, larger compounds tend to be less mobile in biological and environmental systems. Their large size restricts their transport through biological membranes and lowers their vapor pressure. Polymers and oligomers evaluated in this alternatives assessment were mixtures that contain a distribution of components and they may not have a unique MW (see also Section 4.2.3). To account for variation in these mixtures, the average MW or MW_n, determined experimentally (typically using high pressure liquid chromatography, viscosity, or light-scattering), was used in the assessment of polymers. The assessment of polymers also includes oligomers and unchanged monomers (starting materials) that have MW of <1,000 daltons as these were often the highest concern materials (bioavailable substances) in the mixture.

Melting Point and Boiling Point

These two properties provide an indication of the physical state of the material at ambient temperature. Chemicals with a melting point more than 25°C were assessed as a solid. Those with a melting point less than 25°C and a boiling point more than 25°C were assessed as a liquid and those with a boiling point less than 25°C were assessed as a gas. The physical state was used throughout the assessment, such as in the determination of potential routes of human and environmental exposure, as described in Section 5.2. The melting and boiling points were also useful in determining the potential environmental fate, ecotoxicity, and human health hazards of a chemical. For example, organic compounds with high melting points generally have low water solubility and low rates of dissolution. These properties influence a material's bioavailability and were therefore taken into account in both the assessment process and the evaluation of experimental studies. Similarly, chemicals with a low melting point also have a higher potential to be absorbed through the skin, gastrointestinal tract, and lungs.

In the absence of experimental data, the melting point value was not reported and no estimations were performed. If a chemical decomposes before it melts, this information was included in the assessment. For boiling point, the maximum value reported in the assessment was 300°C for high boiling materials including polymers (U.S. EPA 1999b). Melting points for polymers and/or oligomers were not reported as these materials typically reach a softening point and do not undergo the phase change associated with melting (i.e., solid to liquid).

Vapor Pressure

Vapor pressure is useful in determining the potential for a chemical substance to volatilize to the atmosphere from dry surfaces, from storage containers, or during mixing, transfer, or loading/unloading operations (see Section 5.2). In the assessment process, chemicals with a vapor pressure less than 1×10^{-6} mm Hg have a low potential for inhalation exposure resulting from gases or vapors. Vapor pressure is also useful for determining the potential environmental

fate of a substance. Substances with a vapor pressure more than 1×10^{-4} mm Hg generally exist in the gas phase in the atmosphere. Substances with a vapor pressure between 1×10^{-4} and 1×10^{-8} mm Hg exist as a gas/particulate mixture. Substances with a vapor pressure less than 1×10^{-8} mm Hg exist as a particulate. The potential atmospheric degradation processes described below in the reactivity section generally occur when a chemical exists in the gas phase. Gases in the atmosphere also have the potential to travel long distances from their original point of release. Materials in the liquid or solid (particulate) phases in the atmosphere generally undergo deposition onto the Earth's surface.

A maximum vapor pressure of 1×10^{-8} mm Hg was assigned for chemicals without experimental data or for those substances that were anticipated by professional judgment to be nonvolatile (U.S. EPA 2011e). The maximum vapor pressure of 1×10^{-8} mm Hg was also the default value reported for the vapor pressure of polymers with a MW >1,000 daltons (U.S. EPA 2010d).

Water Solubility

The water solubility of a chemical provides an indication of its distribution between environmental media, potential for environmental exposure through release to aquatic compartments, and potential for human exposure through ingestion of drinking water. Water solubility was also used extensively to determine potential human health and ecotoxicity hazards. In general, chemicals with water solubility less than 1×10^{-5} g/L indicate a lower concern for both the expression of adverse effects, and potential aquatic and general population exposure due to their low bioavailability. However, chemicals with a low bioavailability also tend to be more environmentally persistent. Low bioavailability is different than no bioavailability, and the two should not be used interchangeably.

Within the context of this alternatives assessment, the following descriptors were used according to ranges of water solubility values: more than 10,000 mg/L was considered very soluble; 1,000–10,000 mg/L represents soluble; 100–1,000 mg/L represents moderately soluble, 1–100 mg/L represents slightly soluble, and less than 1 mg/L represents insoluble, noting that these guidelines were not followed consistently within the scientific literature (U.S. EPA 2011e). Chemicals with higher water solubility were more likely to be transported into groundwater with runoff during storm events, be absorbed through the gastrointestinal tract or lungs, partition to aquatic compartments, undergo atmospheric removal by rain washout, and possess a greater potential for human exposure through the ingestion of contaminated drinking water. Chemicals with lower water solubility are generally more persistent and have a greater potential to bioconcentrate.

The water solubility of a substance was also used to evaluate the quality of experimental aquatic toxicity and oral exposure human health studies as well as the reliability of aquatic toxicity estimates. If the water solubility of a substance was lower than the reported exposure level in these experiments, then the study was likely to be regarded as inadequate due to potentially confounding factors arising from the presence of un-dissolved material. For aquatic toxicity estimates obtained using SARs, when the estimated toxicity was higher than a chemical's water solubility (i.e., the estimated concentration in water at which adverse effects appear cannot be reached because it was above the material's water solubility), the chemical was described as

having NES. An NES designation is equivalent to a low aquatic toxicity hazard designation for that endpoint.

While assessing the water solubility of a chemical substance, its potential to disperse in an aqueous solution was also considered. Ideally, a chemical's potential to disperse would be obtained from the scientific literature. In the absence of experimental data, the potential for dispersion can be determined from chemical structure and/or comparison to closely related analogs. There are two general structural characteristics that lead to the formation of dispersions in water: (1) chemicals that have both a hydrophilic (polar) head and a hydrophobic (nonpolar) tail (e.g., surfactants), and (2) molecules that have a large number of repeating polar functional groups (e.g., polyethylene oxide).

The potential for a chemical to disperse influences potential exposure, environmental fate, and toxicity. Dispersible chemicals have greater potential for human and environmental exposure, leachability, and aquatic toxicity than what might be anticipated based on the material's water solubility alone.

Chemicals without experimental data or chemicals that were anticipated by professional judgment to be sufficiently insoluble and thus were not bioavailable were assigned a water solubility maximum value of 1×10^{-3} mg/L (U.S. EPA 2011e). A water solubility of 1×10^{-3} mg/L is the default value used for discrete organics as well as non-ionic polymers with a MW >1,000 daltons according to information contained in the literature concerning polymer assessment and the SF Polymer Assessment guidance (U.S. EPA 2010d). This assignment is consistent with an analysis of the chemicals used in the development of the water solubility estimation program in EPA's EPISuite™ software. The training set for this model included 1,450 chemicals with a MW range 27-628 daltons and experimental water solubility values ranging from miscible to 4×10^{-7} mg/L (Meylan, Howard et al. 1996; U.S. EPA 2011i). Given that water solubility decreases with MW, a default value of 1×10^{-3} mg/L is consistent with the limited bioavailability expected for materials with a MW >1,000 daltons.

Octanol/Water Partition Coefficient (K_{ow})

The octanol/water partition coefficient, commonly expressed as its log value (i.e., $\log K_{ow}$) is one of the most useful properties for performing a hazard assessment. The $\log K_{ow}$ indicates the partitioning of a chemical between octanol and water, where octanol is used to mimic fat and other hydrophobic components of biological systems. Chemicals with a $\log K_{ow}$ less than 1 are highly soluble in water (hydrophilic), while those with a $\log K_{ow}$ more than 4 are not very soluble in water (hydrophobic). A $\log K_{ow}$ more than 8 indicates that the chemical is not readily bioavailable and is essentially insoluble in water. In addition, a $\log K_{ow}$ greater than approximately 8 may be difficult to obtain experimentally.

The $\log K_{ow}$ can be used as a surrogate for the water solubility in a hazard assessment and is frequently used to estimate the water solubility if an experimental value is not available. It can also be used to estimate other properties important to the assessment, including bioconcentration and soil adsorption, and is a required input for SAR models used to estimate ecotoxicity values.

For chemicals without data, that are not within the domain of EPISuite™ or that were expected to be insoluble in water ($WS < 1 \times 10^{-3}$ mg/L), a minimum value of 10 was assigned for the log K_{ow} (U.S. EPA 2011e). Insoluble chemicals that could be run through EPISuite™ software may use a log $K_{ow} > 10$ if the result appeared to be valid based on expert review. This assignment is consistent with an analysis of the chemicals (“training set”) used in the development of the octanol/water partition coefficient estimation program in the EPISuite™ software. The training set for this model included 10,946 chemicals with a MW range 18-720 daltons and experimental log K_{ow} values ranging from -3.89 to 8.70 (Meylan and Howard 1995; U.S. EPA 2011h). Given that log K_{ow} increases with MW, a default value of 10 is consistent with the limited bioavailability expected for materials with a MW >1,000 daltons. A maximum log K_{ow} of -2 was used for water soluble materials. For most polymers and other materials that are anticipated to be insoluble in both water and octanol, the log K_{ow} cannot be measured and was therefore not listed.

Flammability (Flash Point)

The flash point of a substance is defined as the minimum temperature at which the substance emits sufficient vapor to form an ignitable mixture with air. Flash point can be used to identify hazards associated with the handling of volatile chemicals. Substances with a flash point above 37.8°C (100°F) were commonly referred to as non-flammable, as this is the flammability definition used in the shipping industry. There are exceptions to this definition such as chemicals that may form explosive mixtures in the presence of air.

Explosivity

Explosivity refers to the potential for a chemical to form explosive mixtures in air and can be defined using the limits of flammability. The lower limit of flammability (LFL) is defined as the minimum concentration of a combustible substance that is capable of propagating a flame through a homogenous mixture in the presence of an ignition source. The upper limit of flammability (UFL) is similarly defined as the highest concentration that can propagate a flame. LFLs and UFLs are commonly reported as the volume percent or volume fraction of the flammable component in air at 25°C. If the ambient air concentration of the gas (or vapor) is between the upper and lower explosion limit, then the material has the potential to explode if it comes in contact with an ignition source. Knowledge regarding the explosivity of a given material in air is also useful in identifying potential hazards associated with the manufacture and use of that material.

pH

The pH scale measures how acidic or basic a substance is on a range from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic, and a pH greater than 7 is basic. This scale is used primarily to identify potential hazards associated with skin or eye contact with a chemical or its aqueous solutions. The corrosive nature of chemicals that form either strongly basic (high pH) or strongly acidic (low pH) solutions are generally likely to result in harm to skin and other biological membranes. For corrosive chemicals, some experimental studies, such as biodegradation tests, require additional analysis to determine if the tests were performed at concentrations that cause harm to microbes in the test (and, therefore, may result in incorrectly identifying a chemical as

persistent in the environment). For chemicals that form moderately basic or acidic solutions in water, the pH of the resulting solution can be used in lieu of a measured dissociation constant.

Dissociation Constant in Water (pKa)

The dissociation constant determines if a chemical will ionize under environmental conditions. The dissociation constant in water provides the amount of the dissociated and undissociated forms of an acid, base, or organic salt in water. Knowledge of the dissociation constant is required to assess the importance of the other physical-chemical properties used in the hazard assessment. As the percentage of ionization increases, the water solubility increases while the vapor pressure, Henry's Law constant, and octanol/water partition coefficient decrease. For acids and bases, the dissociation constant is expressed as the pK_A and pK_B , respectively.

Henry's Law Constant

Henry's Law constant is the ratio of a chemical's concentration in the gas phase to that in the liquid phase (at equilibrium). In environmental assessments, the Henry's Law constant is typically measured in water at 25°C. The Henry's Law constant provides an indication of a chemical's volatility from water, which can be used to derive partitioning within environmental compartments and the amount of material removed by stripping in a sewage treatment plant. Henry's Law constant values less than 1×10^{-7} atm-m³/mole indicate slow volatilization from water to air (the Henry's Law constant for the volatilization of water from water is 1×10^{-7} atm-m³/mole) and values more than 1×10^{-3} atm-m³/mole indicate rapid volatilization from water to air. To aid in determining the importance of volatilization, the assessment uses two models based on the Henry's Law constant. These models determine the half-life for volatilization from a model river and a model lake. A maximum value of 1×10^{-8} atm-m³/mole for the Henry's Law constant was assigned for chemicals without experimental data or for those that were anticipated by professional judgment to be nonvolatile.

Sediment/Soil Adsorption/Desorption Coefficient (K_{oc})

The soil adsorption coefficient provides a measure of a chemical's ability to adsorb to the organic portion of soil and sediment. This provides an indication of the potential for the chemical to leach through soil and be introduced into groundwater, which may lead to environmental exposures to wildlife or humans through the ingestion of drinking water drawn from underground sources. Chemicals with high soil adsorption coefficients are expected to be strongly adsorbed to soil and are unlikely to leach into ground water. The soil adsorption coefficient also describes the potential for a chemical to partition from environmental waters to suspended solids and sediment. The higher the K_{oc} the more strongly a chemical is adsorbed to soil. Strong adsorption may impact other fate processes, such as the rate of biodegradation, by making the chemical less bioavailable.

The soil adsorption coefficient, K_{oc} , is normalized with respect to the organic carbon content of the soil to account for geographic differences. The assignments for the degree that a chemical is adsorbed to soil within the context of the assessment were described qualitatively as very strong (above 30,000), strong (above 3,000), moderate (above 300), low (above 30), and negligible

(above 3). When determining the potential for a chemical to adsorb to soil and suspended organic matter, the potential for a chemical to form chemical bonds with humic acids and attach to soil also needs to be considered, although this process is generally limited to a small number of chemical classes.

A maximum value of 30,000 for the K_{oc} was assigned for chemicals without experimental data or for those that were anticipated by professional judgment to be strongly absorbed to soil (U.S. EPA 2011e). A default K_{oc} of 30,000 was used for polymers with a MW >1,000 daltons.

Reactivity

The potential for a substance to undergo irreversible chemical reactions in the environment can be used in the assessment of persistence. The primary chemical reactions considered in an environmental fate assessment are: hydrolysis, photolysis, and the gas phase reaction with hydroxyl radicals, ozone or nitrate radicals. The most important reaction considered in the hazard assessment of organic compounds is hydrolysis, or the reaction of a chemical substance with water. Because the rate of hydrolysis reactions can change substantially as a function of pH, studies performed in the pH range typically found in the environment (pH 5–9) were considered. The second reaction considered in the assessment is photolysis, the reaction of a chemical with sunlight. Both hydrolysis and photolysis occur in air, water, and soil, while only hydrolysis was considered in sediment. The half-lives for reactive processes, if faster than removal via biodegradation, were used to assign the hazard designation by direct comparison to the DfE persistence criteria.

For the atmospheric compartment, persistence also includes the evaluation of oxidative gas-phase processes. These processes include the reaction with ozone, hydroxyl radicals, and nitrate radicals. Since the average concentration of these oxidative species in the atmosphere has been measured, the experimental or estimated rate constants were converted to, and reported as, a half-life in the assessment using standard pseudo first-order kinetics (U.S. EPA 2011f; U.S. EPA 2011d).

For inorganic compounds, an additional chemical process was considered, the potential to be reduced or oxidized (undergo a redox reaction) under environmental conditions. Redox reactions change the oxidation state of the species through the transfer of electrons to form another compound (such as the reduction of Cr(VI) to Cr(III)). A change in the oxidation state of a metal or inorganic species can result in significant changes in the material's hazard designation. In this example, going from Cr(VI) to Cr(III) makes the compound less toxic.

Environmental Transport

The persistence of a chemical substance is based on determining the importance of removal processes that may occur once a chemical enters the environment. As noted in Section 4.3, chemicals with a half-life of less than 60 days are expected to be at most a Moderate hazard designation for persistence. Persistence does not directly address the pathways in which a chemical substance might enter the environment (e.g., volatilization or disposal in a landfill) and focuses instead on the removal processes that are expected to occur once it is released into air,

water, soil, or sediment. Similarly, the persistence assessment does not address what might happen to a chemical substance throughout its life cycle, such as disposal during incineration of consumer or commercial products. Understanding the environmental transport of a chemical substance can help identify processes relevant to environmental assessment. For example, if a chemical is toxic to benthic organisms and partitions primarily to sediment, its potential release to water should be carefully considered in the selection of alternatives.

Biodegradation

In the absence of rapid hydrolysis or other chemical reactions, biodegradation is typically the primary environmental degradation process for organic compounds. Determining the importance of biodegradation is, therefore, an important component of the assessment. Biodegradation processes are divided into two types. The first is primary biodegradation, in which a chemical substance is converted to another substance. The second is ultimate biodegradation, in which a chemical is completely mineralized to small building-block components (e.g., CO₂ and water). DfE persistence criteria use data that are reported as percent of theoretical ultimate degradation in the guideline Ready Biodegradability test or as a half-life in other experimental studies; both of these measurements can be compared directly to the DfE criteria in 4.1.2. When considering primary degradation, the assessment process includes an evaluation of the potential for the formation of metabolites that were more persistent than the parent materials. Chemical substances that undergo rapid primary degradation but only slow ultimate biodegradation were considered to have stable metabolites. In the absence of measured data on the substance of interest, DfE evaluated the potential for biodegradation for chemicals with a MW <1,000 daltons using the EPA EPISuite™ models. EPISuite™ estimates the probability for ready biodegradation as well as the potential for primary and ultimate removal, as described in Section 4.3. A default Very High persistence hazard designation was assigned for polymers with a MW >1,000 daltons according to information contained in the literature concerning polymer assessment and the SF Polymer Assessment guidance (U.S. EPA 2010d).

4.4 Evaluating Human Health Endpoints

After data collection and analysis of the physical-chemical properties for the chemicals being assessed the comparison of the data against the hazard criteria can begin. Section 4.4.1 discusses how measured data are used to make hazard designations for human health endpoints and Section 4.4.2 presents the approach for filling in data gaps to make these hazard designations.

4.4.1 Endpoints Characterized and Evaluated Against Criteria Based on Measured Data

This section provides a short description of how measured data were used to designate the level of hazard for each endpoint. As a reminder, the criteria for the hazard designations are in Table 4-2.

For acute mammalian toxicity the median lethal doses or concentrations were used to assign the hazard designation. Four levels of hazard designation have been defined ranging from Low to Very High.

For cancer the hazard designation was contingent on the level of evidence for increased incidence of cancer, and not potency. The definitions applied in DfE criteria are based on International Agency for Research on Cancer levels of evidence (International Agency for Research on Cancer 2006). For example, a designation of Very High concern requires that the substance be characterized as a “known or presumed human carcinogen”, whereas a designation of Low concern requires either negative studies or robust SAR conclusions. A designation of Moderate was applied as a default value when there was an absence of data suggesting High carcinogenicity, and an absence of data supporting Low carcinogenicity (i.e., a lack of negative studies or weak SAR conclusions).

Similarly, the hazard designation for mutagenicity/genotoxicity was also based on the level of evidence rather than potency. Complete data requirements for this endpoint were both gene mutation and chromosomal aberration assays. For instances of incomplete or inadequate mutagenicity/genotoxicity data, a Low hazard designation cannot be given.

For chronic endpoints, such as reproductive, developmental, neurological and repeated dose toxicity, the hazard designation was based on potency. The evaluation considers both lowest observed adverse effect levels (LOAELs) and identification of no observed adverse effect levels (NOAELs) when available. The LOAEL and the NOAEL are experimental dose levels, and their reliability is dictated by the study design. In studies for which the lowest dose tested resulted in an adverse effect (and therefore a NOAEL was not established), and in studies for which the highest dose tested was a NOAEL, a conservative approach using professional judgment was used to address uncertainty regarding the lowest dose or exposure level that might be expected to cause a particular adverse effect. For example, in the absence of an established a NOAEL, an identified LOAEL might fall within the range of a Moderate hazard; however, it is uncertain if a lower dose, such as one that falls within the range of High hazard exists because no lower doses were tested. In such cases, professional judgment was applied to assign a hazard designation when possible. Some degree of uncertainty was evident in results from studies in which a NOAEL may fall within one hazard range (e.g., Moderate hazard) and the identified LOAEL falls within a different hazard range (e.g., Low hazard) because the true LOAEL may fall in either category, but there were not enough experimental data points to determine the true LOAEL. Professional judgment was also applied to these cases to assign a hazard descriptor when possible and the rationale used was described in the assessment. Developmental neurotoxicity was considered and was evaluated using the developmental toxicity criteria, which are more stringent than the criteria for neurotoxicity, and thus designed to be more protective (U.S. EPA 2011b).

The criteria for skin and respiratory sensitization, which are immune-based responses, consider the frequency and potency of the reactions. For skin sensitization, categories were based on the weight of evidence¹² from traditional animal bioassays, but *in vitro* alternative studies were also considered. At this time, there are no standard test methods for respiratory sensitization; as a result there was often no designation for this endpoint.

The evaluation of skin and eye irritation and corrosivity were based on the time to recovery.

¹² Generally, weight of evidence is defined as the process for characterizing the extent to which the available data support a hypothesis that an agent causes a particular effect (U.S. EPA 1999a).

4.4.2 SAR – Application of SAR and Expert Judgment to Endpoint Criteria

If measured data pertaining to human health criteria were not available, potential adverse effects were estimated with SAR analysis. To make these estimates, DfE relied on the expertise of scientists in EPA's New Chemicals Program who have reviewed thousands of chemicals and associated data using these methods. SAR uses the molecular structure of a chemical to infer a physicochemical property that can be related to specific effects on human health. These correlations may be qualitative ("simple SAR") or quantitative (QSAR). Information on EPA's use of SAR analysis has been published by U.S. EPA (1994a). Public access to free validated quantitative SAR models for human health endpoints is far more limited than physical-chemical properties, environmental fate parameters, or ecotoxicology. Carcinogenicity was assessed using the OncoLogic expert system that provides a qualitative result directly applicable to the DfE criteria. For other endpoints that required SAR approaches, an analog approach using expert judgment was used as discussed in Section 4.2. All estimates obtained in this project were reviewed by EPA scientists having subject matter expertise. Estimates for the other human health endpoints were based on expert judgment using an analog approach and not through the use of computerized SAR methodologies.

Carcinogenicity

The potential for a chemical to cause cancer in humans was estimated using OncoLogic expert system. This program uses a decision tree based on the known carcinogenicity of chemicals with similar chemical structures, information on mechanisms of action, short-term predictive tests, epidemiological studies, and expert judgment.

Polymer Assessment

Estimates for polymers were obtained using information contained in the literature concerning polymer assessment and the SF Polymer Assessment guidance based on the MW profile (U.S. EPA 2010d). Those polymers with MW >1,000 were assessed using an appropriate representative structure that has a MW less than or equal to the average MW. For polymers with an average MW >1,000 daltons and a significant amount of low MW material <1,000 daltons, the low MW components were also assessed for their environmental fate and potential toxicity in order to identify any possible hazards for the most bioavailable fraction. Similarly, the presence of unreacted monomers requires that the assessment consider these components for polymers of any MW range. The properties for polymers with an average MW >1,000 with no low MW components were generally evaluated as a single high MW material for each of the properties described below. In general, polymers with an average MW >1,000 were not amenable to the available SAR estimation methods and based on the literature are assumed to have low to no bioavailability. Polymers with MW >1,000 that were not degradable or reactive are also typically not bioavailable. Polymers with an average MW >10,000 have potential for adverse effects due to lung overloading when respirable particles are present (less than ten microns). The potential for fibrosis or cancer are not assumed with high MW compounds. There may be exceptions to the rules of thumb outlined above and as such this guidance should not be held as absolute thresholds.

Polymers and oligomers with MWs <1,000 were assessed using a representative structure for all the MW species anticipated to be present in the mixture. The procedures were essentially identical to those employed for the evaluation of impurities or byproducts in discrete chemicals, although in this case the oligomer with the highest concern was used to drive the hazard designation. Unreacted monomers, if present, were also assessed and considered in the hazard evaluation.

4.5 Evaluating Environmental Toxicity and Fate Endpoints

As with endpoints previously mentioned, the preferred method for the evaluation of environmental endpoints is the use of experimental data. In their absence, the alternatives assessment uses computerized QSAR models developed by EPA for the evaluation of environmental endpoints that can be directly compared to the DfE criteria. When measured data were not available, the aquatic toxicity was estimated using EPA's ECOSARTM software and the persistence designation was estimated using models in EPA's EPISuiteTM software. The hazard designation was determined by applying the criteria to these estimates. As a direct result of the design of these models and their direct application to DfE criteria, the evaluation of environmental endpoints using experimental or estimated data was discussed together in the following subsections.

4.5.1 Aquatic Toxicity

For ecological toxicity, the alternatives assessment focused on the hazard designations for acute and chronic studies on freshwater species of algae, invertebrates, and fish, (often referred to as the "three surrogate species"). Aquatic toxicity values were reported in the assessment as follows:

- Acute (estimated or experimental) - LC₅₀ or EC₅₀ in mg/L
- Chronic (experimental) - No observed effect concentration (NOEC) in mg/L
- Chronic (estimated) - ChV, or the geometric mean between the NOEC and the LOEC, in mg/L

Experimental data and estimates reported in the alternatives assessment include information on the species tested and typically focus on freshwater aquatic organisms. Test data on other organisms (e.g., worms) were included in the assessment if data or models were readily available. These data would be evaluated using professional judgment in support of the hazard designations assigned using the three surrogate freshwater species; however, they were not used exclusively to assign a hazard designation as DfE criteria are not available. For the estimated results from ECOSARTM, the equations are derived from surrogate species of fish, zooplankton, and phytoplankton. While these surrogate species can comprise several genera as well as families, the equations are not intended to be species specific, but rather estimate toxicity to the general trophic levels they represent (Mayo-Bean, Nabholz et al. 2011).

If an experimental or estimated effect level exceeded the known water solubility of a chemical substance, or if the log K_{ow} exceeded the ECOSARTM cut-off values for acute and chronic endpoints (which are class specific), No Effects at Saturation (NES) were determined for the aquatic toxicity endpoints. NES indicates that at the highest concentration achievable, which is

the limit of a chemical's water solubility, no adverse effects were observed (or would be expected). In these cases, a Low hazard designation was assigned. In the cases where both an estimated water solubility and ECOSARTM estimate were used, then an additional factor of ten was applied to the water solubility before a NES designation was assigned to account for the combined uncertainty in the model estimates.

In the case where an experimental aquatic toxicity value was significantly higher than the chemical's water solubility, it was likely the result of a poorly conducted study. In this circumstance, which is generally more frequent for formulated products or mixtures, additional details were provided in the data quality section to describe why the reported values could not be used to assign a hazard designation. No effects at saturation are also expected in most cases for insoluble organics, oligomers, or non-ionic polymers with a MW >1,000 daltons resulting in an overall low hazard concern for aquatic toxicity (Nabholz, Clements et al. 1993).

EPA's ECOSARTM estimation program uses chemical structure to estimate toxicity of a substance using class-specific QSARs. ECOSARTM automatically determines all classes that a chemical may be related to based on the molecular features of the substance and, therefore, may provide multiple class-specific estimates for some or all of the species and durations estimated (Mayo-Bean, Nabholz et al. 2011). Modeled results are dependent on the functional groups present on the molecule as well as the diversity of chemicals with experimental data used to build the models (the training set). The hazard profiles report estimates for every class identified by ECOSARTM. However, the hazard designation was based on the most conservative ECOSARTM estimate (highest hazard value). If professional judgment indicates that certain class-specific estimates were not appropriate for a particular substance, the narcosis (baseline toxicity) associated with the neutral organic class will be used. Experimental log K_{ow} values were used preferentially as input into ECOSARTM. In their absence, estimated log K_{ow} values from EPISuiteTM were used. ECOSARTM is maintained and developed as a stand-alone program (<http://www.epa.gov/oppt/newchems/tools/21ecosar.htm>), but is also accessible through the EPA EPISuiteTM program after it is installed; therefore the Estimations Program Interface (EPI) program may also be used as a citation for the ECOSARTM values in this report.

There were instances where sufficient experimental data are not available to build a chronic QSAR for some of the three surrogate species. When ECOSARTM did not provide chronic estimates, the acute value (experimental or estimated) was divided by an acute to chronic ratio (ACR) to arrive at the ChV. ACRs of 10 were used for fish and daphnid and an ACR of 4 was used for algae (Rand, Wells et al. 1995).

4.5.2 Bioaccumulation

Bioaccumulation is a process in which a chemical substance is absorbed in an organism by all routes of exposure as occurs in the natural environment, e.g., from dietary and ambient environment sources. Bioaccumulation is the net result of the competing processes; this includes uptake, metabolism and elimination of a chemical in an organism. Bioaccumulation can be evaluated using the BAF, the steady state ratio of a chemical in an organism relative to its concentration in the ambient environment, where the organism is exposed through ingestion and direct contact. Experimental BAFs have not been widely available in the scientific literature and, as a result, experimental BCFs are more commonly used to evaluate the bioaccumulation hazard.

BCFs are defined as the ratio of the concentration of a chemical in an organism to the concentration of the chemical in the organism's surroundings; BCFs are typically measured for fish (in water) using guideline studies.

Experimental BAF or BCF values can be compared directly to the DfE criteria for this endpoint to assign a hazard designation. The BCF/BAF designations range from <100 for a Low designation to >5,000 for a Very High designation (see 4.1.2). If experimental values were available for both of these endpoints, and the BCF and BAF were >100 (i.e., above the Low designation), the largest factor was used to assign hazard designation. If experimental BCFs <100 were available, the estimated upper trophic BAF from EPISuite™ was used preferentially if its use resulted in a more conservative hazard designation and if the potential for metabolism was accurately accounted for within the model estimates.

In the absence of experimental data, evaluation of bioaccumulation potential can be done using the log K_{ow} and the log octanol/air partition coefficient K_{oa} as estimated by EPISuite™. However, analysis using K_{oa} requires the use of metabolism data for higher trophic, air breathing organisms, which can be difficult to obtain from the scientific literature and cannot be readily estimated. BAFs and BCFs from EPISuite™ were, therefore, typically used for the bioaccumulation hazard designation when experimental data were lacking. These values can be compared directly to DfE criteria and the most conservative result was used for the hazard designation. For chemicals that had estimated bioaccumulation data, available experimental monitoring data were used to provide insight into the reliability of the model results. For example, an estimated Low bioaccumulation potential may be increased to a Moderate designation if a chemical was routinely identified in samples from higher trophic levels, or a High designation if the chemical was routinely measured in animals at the top of the food chain.

An estimate of Low is the default value used for discrete organics with a MW >1,000 daltons in the assignment of bioaccumulation hazard. This assignment is consistent with an analysis of the chemicals used in the development of the bioconcentration and bioaccumulation estimation programs in the EPISuite™ software (U.S. EPA 2011g). The training sets for these models included 527 and 421 chemicals, respectively, with a MW range 68-992 daltons (959 daltons for BAF). Given that BCF and BAF reach a maximum and then decrease with increasing log K_{ow} , a default value of Low is, in general, consistent with the limited bioavailability expected for materials with a MW >1,000 daltons. DfE will use all available well-conducted studies when evaluating bioaccumulation potential for materials with a MW >1,000, including environmental biomonitoring data on higher trophic levels.

In general, for polymers with a MW >1,000 daltons, the default bioaccumulation designation of Low was assigned, arising from their predicted limited bioavailability (U.S. EPA 2010d). A more detailed analysis was performed for compounds at or near this bright line cutoff as well as for polymers with components where residuals <1,000 had the potential to be present.

4.5.3 Environmental Persistence

A chemical's persistence in the environment is evaluated by determining the type and rate of potential removal processes. These removal processes were generally divided into two categories: chemical and biological. Of the chemical degradation processes, an evaluation of

environmental persistence includes the reaction of a chemical with water, also known as hydrolysis, because water is ubiquitous in the environment. Hydrolysis rate constants can be obtained from the literature or estimated, and the resulting half-lives can be compared directly to DfE criteria. For commercial chemicals, hydrolysis tends to be a slower environmental removal process than biodegradation. Direct and indirect photolysis also represents other potential chemical degradation processes that are considered in the alternative assessment, and they are discussed later in this section.

Biodegradation, the most prevalent biological removal process, was divided into two types. The first is primary biodegradation, in which a chemical substance is converted to another substance through a single transformation. The second is ultimate biodegradation, in which a chemical is completely degraded to CO₂, water, and mineral oxides (such as phosphates for chemicals containing phosphorus). DfE criteria utilize ultimate biodegradation preferentially for the persistence hazard designation, although primary removal rates were informative in assigning hazard designations particularly for materials that were transformed slowly, and to a lesser extent for those that are transformed rapidly.

If ultimate biodegradation data were not available, primary removal data were used in some cases. For primary removal processes, the potential for the formation of degradation products that are more persistent than the parent compounds must be considered in the hazard designation. When present, the persistent degradation products should be evaluated for fate and toxicity. Half-life data on the persistent degradation products, if available, were used to determine the assignment for the persistence designation. In the absence of persistent degradation products, primary biodegradation half-life data were compared directly to the DfE criteria to assign a hazard designation.

Biodegradation processes can be classified as either aerobic or anaerobic. Aerobic biodegradation is an oxidative process that occurs in the presence of oxygen. Anaerobic biodegradation is a reductive process that occurs only in the absence of oxygen. Aerobic biodegradation is typically assessed for soil and water, while anaerobic biodegradation is generally assessed in sediment. For determining the persistence hazard, the importance of both aerobic and anaerobic biodegradation as well as partitioning and transport in the environment were considered to determine what removal processes were most likely to occur. Anaerobic degradation may use any of several electron acceptors depending on their availability in a given environment and the prevailing redox potential (E_h). The biodegradative populations that are dominant in a given environment vary with the conditions and so do their biodegradative capabilities.

One aspect of the assessment is to determine the potential for removal of a chemical substance, and especially removal attributable to biodegradation within a sewage treatment plant and other environments. In this assessment, the term “ready biodegradability” refers to a chemical’s potential to undergo ultimate degradation in guideline laboratory studies. A positive result in a test for ready biodegradability can be considered as indicative of rapid and ultimate degradation in most environments including biological sewage treatment plants. Ready tests typically include a 10-day window, beginning when the biodegradation parameter (e.g., disappearance of dissolved organic carbon from test substance, or theoretical oxygen demand) reaches 10%. The

10-day window must occur within the 28-day length of the test. If the pass level of the test (60% for oxygen demand and CO₂ production; 70% for dissolved organic carbon disappearance) is met in the 10-day window, the chemical received a Very Low hazard designation. Those that did not pass the 10-day window criterion but met the pass level in 28 days received a Low hazard designation. If ready biodegradability test data were available but the chemical did not meet the pass level, the chemical was evaluated based on measured data using the DfE half-life criteria (Table 4-1). These half-life criteria were also used to assign a hazard designation for nonguideline ultimate biodegradation studies reported in the scientific literature.

In the absence of a reported half-life, experimental data were also used to approximate half-life as appropriate. For example, a chemical that undergoes <5% removal in 30 days would be expected to have a half-life >60 days and would be assigned a High persistence concern.

When experimental data on the biodegradation of a chemical substance were not available, the potential of that substance to undergo this removal process was assessed from the results of the EPISuiteTM models. These models fall into one of four classes: Rapid biodegradation models based on linear and non-linear regressions that estimate the probability that a chemical substance will degrade fast; expert survey models that estimated the rate of ultimate and primary biodegradation using semi-quantitative methods; probability of ready biodegradability in the Organisation of Economic Cooperation and Development (OECD) 301C test; and probability of rapid biodegradation under methanogenic anaerobic conditions. Each of these is discussed in the following paragraphs.

The first models (Biowin 5 and 6) used in the screening assessment estimated ready biodegradability in the OECD 301C test and are also known as Japanese Ministry of International Trade and Industry (MITI) models. These models provided the probability that a material passes this standardized test. Those chemicals that were estimated to pass the ready biodegradability test received a Low persistence designation. If a chemical was not estimated to pass the MITI test, the results of the other EPISuiteTM biodegradation models were used.

The rapid biodegradation potential models within EPISuiteTM (Biowin 1 and 2) were useful for determining if a chemical substance was expected to biodegrade quickly in the environment. If a chemical was likely to biodegrade quickly, it was generally assigned a Low hazard designation for persistence. The results of the estimates from these models may be used in concert with the semi-quantitative output from a second set of models, which include ultimate and primary biodegradation survey models (Biowin 3 and 4) for evaluating persistence. These models provided a numeric result, ranging from 1 to 5, which relates to the amount of time required for complete ultimate degradation (Biowin 3) and removal of the parent substance by primary degradation (Biowin 4) of the test compound. The numeric result from Biowin 3 was converted to an estimated half-life for removal that can be compared directly to DfE criteria. If results from different models (other than the MITI models) led to a different hazard designation, then the ultimate biodegradation model results were used preferentially. If the transport properties indicate the potential for the material to partition to sediment, an anoxic compartment, then the results of the anaerobic probability model (Biowin 7) will also be evaluated.

Half-lives for hydrolysis from experimental studies or EPISuite™ estimates were used in preference to biodegradation data when they suggested that hydrolysis is a more rapid removal process. Hydrolysis half-lives were compared directly to DfE criteria to assign the persistence designation. Similar to primary biodegradation, breakdown products resulting from hydrolysis were evaluated for fate and toxicity when they were expected to be more persistent than the parent compound.

Photolysis may also be an important environmental removal process. In general, environmental removal rates from photolysis do not compete with biodegradation or hydrolysis although there are exceptions such as iodides. Photolysis may be an important removal process for chemicals that were not bioavailable because of their limited water solubility. Estimation methods for photolysis rates were not available using computerized SAR tools. If experimental or suitable analog data were available, the rate of photolysis was evaluated relative to other removal processes.

When evaluating the environmental persistence designation, it should be noted that chemicals with a High or Very High designation can degrade over time, although this process may occur at a very slow rate. As a result, a Very High designation may have been assigned if persistent degradates were expected to be produced, even at a very slow rate, in the absence of experimental biodegradation data for the parent substance.

Chemicals that contain a metal were assigned a High persistence designation in the assessment, as these inorganic moieties are recalcitrant. In this instance, an ‘R’ footnote was added to the hazard summary table to indicate that the persistence potential was based on the presence of a recalcitrant inorganic moiety. The assessment process also included the evaluation of the potential chemical reactions of metal-containing and inorganic moieties to determine if they were potentially transformed to more or less hazardous forms.

Polymers with a MW >1,000 generally received a Very High persistence designation due to their lack of bioavailability.

4.6 Endocrine Activity

Chemicals included in DfE alternatives assessments were screened for potential endocrine activity, consistent with the DfE Alternatives Assessment Criteria. **Endocrine activity** refers to a change in endocrine homeostasis caused by a chemical or other stressor. An **endocrine disruptor** is an external agent that interferes in some way with the role of natural hormones in the body, in a manner causing adverse effects. Relevant data are summarized in the hazard assessments for each chemical, located in Section 4.8. Data on endocrine activity were available for decaBDE and some of the alternatives included in this report. For chemicals without available data on endocrine activity, this was acknowledged with a “no data located” statement. When endocrine activity data were available, the data are summarized as a narrative. A unique hazard designation of Low, Moderate or High is not provided for this endpoint in Table 4-2, for reasons discussed below.

The document *Special Report on Environmental Endocrine Disruption: An Effects Assessment and Analysis* describes EPA’s activities regarding the evaluation of endocrine disruption (U.S.

EPA 1997). This report was requested by the Science Policy Council and prepared by EPA's Risk Assessment Forum. This report states that "Based on the current state of the science, the Agency does not consider endocrine disruption to be an adverse endpoint per se, but rather to be a mode or mechanism of action potentially leading to other outcomes, for example, carcinogenic, reproductive or developmental effects, routinely considered in reaching regulatory decisions" (U.S. EPA 1997). The report also states that "Evidence of endocrine disruption alone can influence priority setting for further testing and the assessment of results of this testing could lead to regulatory action if adverse effects are shown to occur" (U.S. EPA 1997).

The 1996 Food Quality Protection Act (FQPA) directed EPA to develop a scientifically validated screening program to determine whether certain substances may cause hormonal effects in humans. In response, EPA established the Endocrine Disruptor Screening Program (EDSP) (U.S. EPA 2012b). The EDSP is developing requirements for the screening and testing of thousands of chemicals for their potential to affect the endocrine system. When complete, EPA will use these screening and testing approaches to set priorities and conduct further testing when warranted. The science related to measuring and demonstrating endocrine disruption is relatively new, and validated testing methods at EPA are still being developed.

The EDSP proposes a two-tiered approach that includes initial screening followed by more in-depth testing when warranted (U.S. EPA 2011a). The Tier 1 screening battery is intended to identify chemicals with the potential to interact with the estrogen, androgen, or thyroid hormone systems through any of several recognized modes of action. Positive findings for Tier 1 tests identify the potential for an interaction with endocrine systems, but do not fully characterize the nature of possible effects in whole animals. Tier 2 testing is intended to confirm, characterize, and quantify the effects for chemicals that interact with estrogen, androgen, and thyroid hormone systems. These test methods must undergo a four-stage validation process (protocol development, optimization/prevalidation, validation, and peer-review) prior to regulatory acceptance and implementation. Validation is ongoing for Tier 1 and Tier 2 methods¹³. Once validated test methods have been established for screening and testing of potential endocrine disruptors, guidance must be developed for interpretation of these test results using an overall weight-of-evidence characterization.

To assess the data on endocrine activity, DfE applies the weight of evidence approach developed by the EDSP (U.S. EPA 2011c). This process integrates and evaluates data, and always relies on professional judgment (U.S. EPA 2011c). To evaluate endocrine activity with this weight of evidence approach, DfE examined multiple lines of evidence (when available) and considered the nature of the effects within and across studies, including number, type, and severity/magnitude of effects, conditions under which effects occurred (e.g., dose, route, duration), consistency, pattern, range, and interrelationships of effects observed within and among studies, species, strains, and sexes, strengths and limitations of the *in vitro* and *in vivo* information, and biological plausibility of the potential for an interaction with the endocrine, androgen, or thyroid hormonal pathways.

Most test data for chemicals in this report consist of *in vitro* assays, but results of *in vitro* assays

¹³ Information on the status of assay development and validation efforts for each assay in EPA's EDSP can be found at: <http://www.epa.gov/oscpmont/oscpendo/pubs/assayvalidation/status.htm>

alone were not generally expected to provide a sufficient basis to support a hazard designation for endocrine disruption. EPA expects that *in vivo* evidence would typically be given greater

Chemical Alternatives and the Toxic Substances Control Act

EPA's DfE program is administered by the Office of Pollution Prevention and Toxics (OPPT), which is charged with the implementation of the Toxic Substances Control Act (TSCA) and the Pollution Prevention Act (PPA).

Central to the administration of TSCA is the management of the TSCA Inventory. [Section 8 \(b\)](#) of TSCA requires EPA to compile, keep current, and publish a list of each chemical substance that is manufactured or processed in the United States. Companies are required to verify the TSCA status of any substance they wish to manufacture or import for a TSCA-related purpose. For more information, please refer to the TSCA Chemical Substance Inventory website: <http://www.epa.gov/opptintr/existingchemicals/pubs/tscainventory/basic.html>.

TSCA and DfE Alternatives Assessments

Substances selected for evaluation in a DfE Alternatives Assessment generally fall under the TSCA regulations and therefore must be listed on the TSCA inventory, or be exempt or excluded from reporting before being manufactured in or imported to, or otherwise introduced in commerce in, the United States. For more information see <http://www.epa.gov/oppt/newchemicals/pubs/whofiles.htm>.

To be as inclusive as possible, DfE Alternatives Assessments may consider substances that may not have been reviewed under TSCA, and therefore may not be listed on the TSCA inventory. DfE has worked with stakeholders to identify and include chemicals that are of interest and likely to be functional alternatives, **regardless of their TSCA status.** Chemical identities are gathered from the scientific literature and from stakeholders and, for non-confidential substances, appropriate TSCA identities are provided.

Persons are advised that substances, including DfE-identified functional alternatives, may not be introduced into U.S. commerce unless they are in compliance with TSCA. Introducing such substances without adhering to the TSCA provisions may be a violation of applicable law. Those who are considering using a substance discussed in this report should check with the manufacturer or importer about the substance's TSCA status. If you have questions about reportability of substances under TSCA, please contact the OPPT Industrial Chemistry Branch at 202-564-8740.

overall influence in the weight of evidence evaluation than *in vitro* findings because of the inherent limitations of such assays. Although *in vitro* assays can provide insight into the mode of action, they have limited ability to account for normal metabolic activation and clearance of the compound, as well as normal intact physiological conditions (e.g., the ability of an animal to compensate for endocrine alterations).

As described in the DfE Alternatives Assessment Criteria, endocrine activity was summarized in a narrative, rather than by High, Moderate or Low hazard designation. The endocrine activity summaries can be found in the hazard profiles. This is an appropriate approach because there is no consensus on what constitutes high, moderate or low concern for this endpoint. The summary of endocrine activity largely relies on representative studies and expert review summaries.

4.7 Hazard Summary Table

Table 4-4 Screening Level Hazard Summary for DecaBDE and Halogenated Flame Retardant Alternatives

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from predictive models and/or professional judgment.

^s Based on analogy to experimental data for a structurally similar compound. [□] This alternative may contain impurities. These impurities have hazard designations that differ from the flame retardant alternative, Brominated poly(phenylether), as follows, based on experimental data: HIGH for human health, HIGH for aquatic toxicity, VERY HIGH for bioaccumulation, and VERY HIGH for persistence. ^T This chemical is subject to testing in an EPA consent order for this endpoint.

Chemical (for full chemical name and relevant trade names see the individual profiles in Section 4.8)	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
DecaBDE and Halogenated Flame Retardant Alternatives																
DecaBDE and Discrete Halogenated FR Alternatives																
Bis(hexachlorocyclopentadieno) Cyclooctane	13560-89-9	L	M ^s	M ^s	VL	VL	L	M	L		VL	L	L	L	VH	H
Brominated Poly(phenylether)	Confidential	L	L [□]	L	VL [□]	M [□]	L [□]	L [□]	L		L	VL	L	L [□]	VH ^T	H ^{T□}
Decabromodiphenyl Ethane	84852-53-9	L	M ^s	L	L	H ^s	L	L	L		VL	VL	L	L	VH	H
Decabromodiphenyl Ether	1163-19-5	L	M	L	L	H	L	M	L		L	L	L	L	VH	H
Ethylene Bis-Tetrabromophthalimide	32588-76-4	L	M	L	L	M ^s	L	L	L		VL	VL	L	L	VH	H
Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether	21850-44-2	L	M	M	M	M	L	M	L		L	L	L	L	VH	H
Tris(tribromoneopentyl) Phosphate	19186-97-1	M	M	L	M	M	H	L	L		L	L	L	L	H	M
Tris(tribromophenoxy) Triazine	25713-60-4	L	L	L	L	L	L	L	L		L	VL	L	L	VH	H

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Table 4-4 Continued

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from predictive models and/or professional judgment. ^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations. ♦ Different formulations of the commercial product are available. One of these many formulations has an average MW of ~1,600 and contains significant amounts of lower MW components. These lower MW components have hazard designations different than the polymeric flame retardant, as follows: HIGH (estimated) for bioaccumulation; HIGH (experimental) for acute aquatic toxicity; HIGH estimated for chronic aquatic toxicity; MODERATE (experimental) for developmental; and MODERATE (estimated) for carcinogenicity, genotoxicity, repeated dose, reproductive, and skin and respiratory sensitization toxicity.																
Chemical (for full chemical name and relevant trade names see the individual profiles in Section 4.8)	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Halogenated Flame Retardant Alternatives Continued																
Polymeric Halogenated FR Alternatives ^p																
Brominated Epoxy Polymers	68928-70-1	L	L♦	L	L♦	L♦	L	L♦ ^d	L	♦	L	L	L♦	L♦	VH	L♦
Brominated Epoxy Polymer(s)	Confidential	L	L♦	L♦	L♦	L♦	L	L♦ ^d	L♦	♦	L	L	L♦	L♦	VH	L♦
Mixture of brominated epoxy polymer(s) and bromobenzyl acrylate	Confidential	L	L♦	L♦	L♦	L♦	L	L♦ ^d	L♦	♦	L	L	L♦	L♦	VH	L♦
Brominated Epoxy Resin End-Capped with Tribromophenol	135229-48-0	L	L	L	L	L	L	L ^d	L		L	VL	L	L	VH	L
Brominated Polyacrylate	59447-57-3	L	L	L	L	L	L	L ^d	L		L	L	L	L	VH	L
Brominated Polystyrene	88497-56-7	L	L	L	L	L	L	L ^d	L		L	L	L	L	VH	L

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

^p The range of polymer molecular weight can be broad. The polymers listed here have low toxicity for human health and aquatic endpoints. Not all polymers will have this low toxicity; hazards will vary with physical-chemical properties.

Table 4-5 Screening Level Hazard Summary for Organic Phosphorus or Nitrogen Flame Retardant Alternatives

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from predictive models and/or professional judgment.

[§] Based on analogy to experimental data for a structurally similar compound.

[‡] The highest hazard designation of any of the oligomers with MW <1,000.

[◇] The highest hazard designation of a representative component of the oligomeric mixture with MWs <1,000.

Chemical (for full chemical name and relevant trade names see the individual profiles in Section 4.8)	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Organic Phosphorus or Nitrogen Flame Retardant (PFR or NFR) Alternatives																
Discrete PFR, NFR and P/NFR Alternatives																
Substituted Amine Phosphate Mixture ¹	Confidential	H	M	M	M	M	L	M	L	M [§]	M	VL	M	L	H	L
Triphenyl Phosphate	115-86-6	L	M	L	L	L	L	H	L		L	VL	VH	VH	L	M
Polymeric PFR and NFR Alternatives																
Bisphenol A bis-(diphenyl phosphate); BAPP	181028-79-5	L	M	L	L	L [§]	L [§]	L	L		L	L	L	L	H	H [◇]
Melamine Cyanurate ¹	37640-57-6	L	M	M	M [§]	M [§]	L	H	L		L	L	L	L	VH	L
Melamine Polyphosphate ¹	15541-60-3	L	M	M	L [§]	L	L [§]	M	L		L	VL	L	L	H	L
N-alkoxy Hindered Amine Reaction Products	191680-81-6	L	M	L	H	H	L	H	L		L	VL	H	H	H	H [‡]

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

¹ Hazard designations are based upon the component of the salt with the highest hazard designation, including the corresponding free acid or base.

Table 4-5 Continued

VL = Very Low hazard **L** = Low hazard **M** = Moderate hazard **H** = High hazard **VH** = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from predictive models and/or professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations

[§] Based on analogy to experimental data for a structurally similar compound.

[‡] The highest hazard designation of any of the oligomers with MW <1,000.

[¥] Phosphonate Oligomer, with a MW range of 1,000 to 5,000, may contain significant amounts of an impurity, depending on the final product preparation. This impurity has hazard designations that differ from the polymeric flame retardant, as follows: MODERATE (experimental) for carcinogenicity, reproductive and repeated dose toxicity, skin sensitization, eye and dermal irritation; and HIGH (experimental) for developmental toxicity and acute and chronic aquatic toxicity.

Chemical (for full chemical name and relevant trade names see the individual profiles in Section 4.8)	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Organic Phosphorus or Nitrogen Flame Retardant (PFR or NFR) Alternatives Continued																
Polymeric PFR and NFR Alternatives																
Phosphonate Oligomer [¥]	68664-06-2	L	M	L [§]	L [¥]	L [¥]	M [‡]	L ^{§¥}	L ^{§¥}		M ^{‡¥}	M [‡]	L [¥]	H [‡]	VH	H [‡]
Polyphosphonate	68664-06-2	L	L	L	L	L	L	L ^d	L		L	L	L	L	VH	L
Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol; BPBP	1003300-73-9	L	M	L	L [§]	L [§]	L	L	L		VL	VL	H [§]	H [§]	H	M [‡]
Poly[phosphonate-co-carbonate]	77226-90-5	L	L	L	L	L	L	L ^d	L		L	L	L	L	VH	L
Resorcinol Bis-Diphenylphosphate; RDP	125997-21-9	L	M [§]	L	L	M	M	M	L		L	VL	VH	VH	M	H [‡]

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Table 4-6 Screening Level Hazard Summary for Inorganic Flame Retardant Alternatives

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from predictive models and/or professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

^R Recalcitrant: Substance is comprised of metallic species that will not degrade, but may change oxidation state or undergo complexation processes under environmental conditions.

* Ongoing studies may result in a change in this endpoint.

Chemical (for full chemical name and relevant trade names see the individual profiles in Section 4.8)	CASRN	Human Health Effects											Aquatic Toxicity **		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Inorganic Flame Retardant Alternatives																
Aluminum Diethylphosphinate	225789-38-8	L	L	L	VL	M	M	M	L		L	VL	M	M	H ^R	L
Aluminum Hydroxide	21645-51-2	L	L	L	L	L	M	M	L		VL	VL	M	M	H ^R	L
Ammonium Polyphosphate	68333-79-9	L	L	L	L	L	L	L ^d	L		VL	L	L	L	VH	L
Antimony Trioxide ¹	1309-64-4	L	M*	M	M	L	L	H	L		L	M	H	M	H ^R	L
Magnesium Hydroxide	1309-42-8	L	L	L	L	L	L	L	L		M	L	L	L	H ^R	L
Red Phosphorus	7723-14-0	L	L	M	L	L	L	L	L		M	M	L	L	H	L
Zinc Borate	1332-07-6	L	L	H	M	M	H	L	L		L	L	H	H	H ^R	L

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

¹ This compound is included in the ongoing EPA Work Plan evaluation for Antimony Trioxide.

4.8 Hazard Evaluations

Aluminum Diethylphosphinate

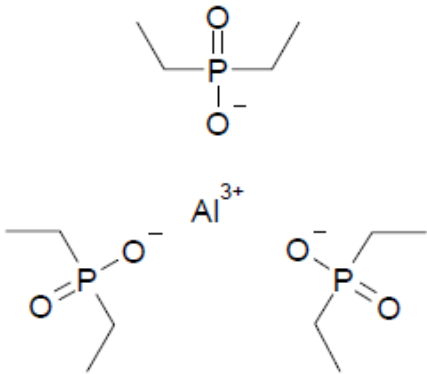
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment. ^R Recalcitrant: Substance is comprised of metallic species that will not degrade, but may change oxidation state or undergo complexation processes under environmental conditions.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Aluminum Diethylphosphinate	225789-38-8	L	L	L	VL	M	M	M	L		L	VL	M	M	H ^R	L

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Aluminum Diethylphosphinate

		CASRN: 225789-38-8
		MW: 390.27
		MF: 3 C ₄ H ₁₁ PO ₂ ·Al
		Physical Forms: Neat: Solid
		Use: Flame retardant
SMILES: CCP(=O)(CC)O[Al](OP(=O)(CC)CC)OP(=O)(CC)CC		
Synonyms: Exolit OP 930; Aluminium diethylphosphinate; Aluminium tris(diethylphosphinate)		
Chemical Considerations: This alternative is an inorganic compound and in the absence of experimental data, professional judgment using chemical class and structural considerations were used to complete this hazard profile.		
Polymeric: No		
Oligomers: Not applicable		
Metabolites, Degradates and Transformation Products: None		
Analog: Confidential aluminum metal salts Endpoint(s) using analog values: Absorption, distribution, metabolism & excretion, carcinogenicity, developmental toxicity, immunotoxicity, neurotoxicity, repeated dose effects		Analog Structure: Not applicable
Structural Alerts: Not applicable		
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).		
Hazard and Risk Assessments: Hazard assessment in Design for the Environment Alternatives Assessment for Flame Retardants in Printed Circuit Boards, Review Draft, November 8, 2008 (EPA, 2008).		

Aluminum Diethylphosphinate CASRN 225789-38-8

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	Decomposes at 315 (Measured)	Submitted confidential study	Adequate.
	Decomposes at 300 (Measured)	Submitted confidential study	
	>400 according to EU Method A.1 using differential scanning calorimetry (Measured)	ECHA, 2013; Submitted confidential study	
	Decomposes at 330 (Measured)	De Boysère and Dietz, 2005	Sufficient details were not available to assess the quality of this study.
	Decomposes at >300 (Measured)	Clariant, 2007	Sufficient details were not available to assess the quality of this study.
	>400 (Measured)	NICNAS, 2005	Sufficient details were not available to assess the quality of this study. Reported for a commercial formulation.
Boiling Point (°C)	Expected to decompose before boiling (Estimated)	Professional judgment	Based on available data for melting point.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; EPA, 1999	Cutoff value for compounds that are anticipated to be nonvolatile, according to HPV assessment guidance.

Aluminum Diethylphosphinate CASRN 225789-38-8

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Water Solubility (mg/L)	2.5×10 ³ (Measured)	Submitted confidential study	Sufficient details were not available to assess the quality of this study. Aluminum diethylphosphinate has low wettability and very slow dissolution. This gives a kinetically controlled solubility of <1 mg/L by guideline 92/69/ European Economic Community (EEC) A.6. If aluminum diethylphosphinate is formed by precipitation of a soluble salt, the remaining equilibrium solubility of 2.5×10 ³ mg/L is found. This can be assumed to be the true limit of solubility under ideal conditions.
	<1 (Measured) According to EU Method A.6	ECHA, 2013; Submitted confidential study	Guideline study; aluminum diethylphosphinate has low wettability and very slow dissolution. If aluminum diethylphosphinate is formed by precipitation of a soluble salt, the remaining equilibrium solubility of 2.5×10 ³ mg/L is found, which can be assumed to be the true limit of solubility under ideal conditions.
	<1 (Measured) According to EU Method A.6	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation.
Log K_{ow}	-0.44 (Estimated)	Stuer-Lauridsen et al., 2007; Beard and Marzi, 2005	Reported in a secondary source; it is unclear whether this value reflects the chemical's low water solubility or its lipophobicity.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Flammability (Flash Point)	Not readily combustible according to guideline 96/69/EEC, test A.10. (Measured)	Submitted confidential study	Guideline study.
	No self-ignition below 402°C (Measured)	ECHA, 2013; Submitted confidential study	Adequate.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Pyrolysis	Major products are diethylphosphinic acid, ethylphosphonic acid, phosphoric acid, and their respective salts (Measured)	Beard and Marzi, 2005	Study details and test conditions were not available.
pH	4.0 (Measured)	Beard and Marzi, 2005	Value was reported in conference presentation authored by Clariant Corp. and UMSICHT. Value suggests the potential for dissolution.
pK_a	Dissociated within 24 hours at pH 4.5 during Japanese Ministry of International Trade and Industry (MITI) test (Measured)	NICNAS, 2005	Available data suggest that this compound is likely to dissociate under environmental conditions. However, it has potential for dissociation as a function of pH that will have a significant influence on its environmental fate. Available data are not adequate to assess its dissociation under typical environmental conditions. Reported for a commercial formulation.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		Based on estimates of physical and chemical properties, analogs, and professional judgment, aluminum diethylphosphinate is determined to not be readily absorbed through skin but is absorbed through the inhalation of dust and oral exposure.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Absorption as neat solid negligible through skin. Absorption good through lungs. Absorption good through gastrointestinal tract. (Estimated)	Professional judgment	Estimates based on physical/chemical properties and confidential analogs.
		Male rats (2/dose group) administered (unradiolabeled) test substance via single oral gavage at 180 and 1,000 mg/kg bw/day. Only a small amount of the administered dose was absorbed by the gastro-intestinal tract. The major route of elimination was in the feces (unabsorbed fraction) and a small amount of free test substance was detected in the urine. After 36 hours, no test substance was detected.	Submitted confidential study	Study details from an abstract reported in a confidential submission; study conducted according to Organisation of Economic Cooperation and Development (OECD) 417; small number of animals tested.
Acute Mammalian Toxicity		LOW: Experimental studies indicate that oral and dermal routes to rats do not produce substantial mortality at levels up to 2,000 mg/kg. No lethality data were located for inhalation exposure.		
Acute Lethality	Oral	Rat oral LD ₅₀ >2,000 mg/kg	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation. Test substance was Exolit OP 930.
	Dermal	Rat dermal LD ₅₀ >2,000 mg/kg	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation. Test substance was Exolit OP 930.
	Inhalation			No data located.
Carcinogenicity		LOW: Aluminum diethylphosphinate is estimated to be of low hazard for carcinogenicity based on comparison to analogous metal salts and professional judgment.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	Not expected to be carcinogenic (Estimated)	Professional judgment	Estimated based on analogy to confidential metal salts.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		LOW: Experimental studies indicate that aluminum diethylphosphinate does not cause gene mutations in bacteria or chromosomal aberrations in mammalian cells.		
	Gene Mutation <i>in vitro</i>	Negative, <i>Salmonella typhimurium</i> strains TA1535, TA1537, TA98 and TA100 with and without metabolic activation	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative, chromosomal aberrations in Chinese hamster lung cells with and without metabolic activation	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation.
	Chromosomal Aberrations <i>in vivo</i>	Negative, mammalian erythrocyte micronucleus test in NMRI mice; oral (unspecified)	Submitted confidential study	Study reported in a submitted confidential study; Study conducted according to OECD Guideline 474 (Mammalian Erythrocyte Micronucleus Test).
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		VERY LOW: There were no reproductive effects reported in a reproduction/developmental toxicity screen in rats at doses up to 1,000 mg/kg-day. In addition, aluminum diethylphosphinate is estimated to be of low hazard for reproductive effects resulting from the presence of a bioavailable metal species, by professional judgment based on a comparison to analogous metal salts.		
	Reproduction/ Developmental Toxicity Screen	Expected to have low hazard potential for reproductive effects (Estimated)	Professional judgment	Estimated based on analogy to confidential metal salts.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Rats (Sprague Dawley); oral administration of 250 and 1,000 mg/kg bw-day; 15 days prior to mating and throughout gestation and lactation up to post-partum Day 3. No clinical signs of toxicity or change in food consumption. Slight reduction in body weight and body weight gain (both sexes, 1,000 mg/kg-day); Reduced terminal body weight and absolute and relative kidney weights (males, 1,000 mg/kg-day). No adverse effect on oestrus cycle, implantation, gestation length, corpora lutea or sex ratios. No effect on sperm (motility, morphology, concentration). Increase in the number of days of pre-coital interval and a reduction in copulation plugs (1,000 mg/kg-day). No treatment-related macroscopic anomalies in pups dying or sacrificed at term. NOAEL = 1,000 mg/kg-day	Submitted confidential study	Study reported in a submitted confidential study; Study conducted according to OECD Guideline 421 (Reproductive/Developmental Toxicity Screening Test).
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Developmental Effects		MODERATE: There were no developmental effects reported in a reproduction/developmental toxicity screen in rats at doses up to 1,000 mg/kg-day. There is moderate hazard for aluminum diethylphosphinate given exposure may result in neurodevelopmental effects based on the presence of a phosphinate; there were no experimental studies specifically designed to evaluate the neurodevelopmental endpoint located. The potential for neurodevelopmental effects cannot be ruled out.		
	Reproduction/ Developmental Toxicity Screen	Expected to have a moderate hazard potential for developmental and neurodevelopmental effects resulting from the presence of a phosphinate. (Estimated)	Professional judgment	Estimated based on analogy to phosphate esters and associated cholinesterase inhibition.

Aluminum Diethylphosphinate CASRN 225789-38-8

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Rats (Sprague Dawley); oral administration of 250 and 1,000 mg/kg bw-day; 15 days prior to mating and throughout gestation and lactation up to post-partum Day 3. No clinical signs of toxicity or change in food consumption. Slight reduction in body weight and body weight gain; reduced terminal body weight and absolute and relative kidney weights (males, 1,000 mg/kg-day). No adverse effect on estrus cycle, implantation, gestation length, corpora lutea or sex ratios. No effect on sperm (motility, morphology, concentration). Increase in the number of days of pre-coital interval and a reduction in copulation plugs (1,000 mg/kg-day). No treatment-related macroscopic anomalies in pups dying or sacrificed at term. NOAEL = 1,000 mg/kg-day	Submitted confidential study	Study details reported in a confidential submission; Study conducted according to OECD Guideline 421 (Reproductive/Developmental Toxicity Screening Test).
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development			No data located.
	Postnatal Development			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Neurotoxicity		MODERATE: Aluminum diethylphosphinate is estimated to be of moderate hazard for neurotoxicity, due to the presence of a bioavailable metal species and based on comparison to aluminum hydroxide with professional judgment.		
	Neurotoxicity Screening Battery (Adult)	Expected to have a moderate hazard potential for neurotoxic effects resulting from the presence of bioavailable metal species. (Estimated)	Professional judgment	Estimated based on professional judgment and analogy to aluminum hydroxide.
		Rat NOAEL >1,000 mg/kg	Beard and Marzi, 2005	Study details and test conditions were not available.
		90-day Rat, oral gavage, impaired learning in a labyrinth maze test NOAEL = Not established LOAEL = 35 mg Al/kg-day as aluminum hydroxide with citric acid (only dose tested) (Estimated by analogy)	Bilkei-Gorzo, 1993 (as cited in ATSDR, 2008)	Reported in a secondary source; dose reported as 35 mg/kg-day as aluminum hydroxide with citric acid; citric acid was added to increase absorption; it is not proven that negative effects only related to aluminum hydroxide and not based on citric acid; also, the background aluminum content of the diet fed to rats was not reported; only one dose tested.
		90-day Rat, oral gavage, impaired learning in a labyrinth maze test NOAEL = Not established LOAEL = 300 mg Al/kg-day as aluminum hydroxide (only dose tested) (Estimated by analogy)	Bilkei-Gorzo, 1993	The background aluminum content of the diet fed to rats was not reported; only one dose tested; study description lacks sufficient details on individual results.
Repeated Dose Effects		MODERATE: Estimated to be of moderate hazard for immunotoxicity, due to the presence of a bioavailable metal species, based on comparison to analogous metal salts and professional judgment. Experimental studies indicate that oral exposure to rats produces no adverse effects at levels up to 1,000 mg/kg-day.		
		28- day NOAEL >1,000 mg/kg-day, rats	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation. Test substance was Exolit OP 930.

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Aluminum Diethylphosphinate CASRN 225789-38-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Immune System Effects	Expected to have a moderate hazard potential for immunotoxicity effects resulting from the presence of bioavailable metal species.(Estimated)	Professional judgment	Estimated based on analogy to confidential metal salts.
Skin Sensitization		LOW: Negative for skin sensitization in guinea pigs.		
	Skin Sensitization	Non-sensitizing, guinea pigs	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation.
Respiratory Sensitization		No data located.		
	Respiratory Irritation			No data located.
Eye Irritation		LOW: Aluminum diethylphosphinate is slightly to non-irritating in rabbit eyes.		
	Eye Irritation	Slightly irritating, rabbits	NICNAS, 2005	Reported in a secondary source for a commercial formulation.
		Not irritating, rabbits	Submitted confidential study	Study reported in a submitted confidential study.
Dermal Irritation		VERY LOW: Aluminum diethylphosphinate is not irritating to rabbit skin.		
	Dermal Irritation	Non-irritating, rabbit	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation.
Endocrine Activity		No data located.		
				No data located.
Immunotoxicity		Aluminum diethylphosphinate is estimated to be of moderate hazard for immunotoxicity, due to the presence of a bioavailable metal species, based on comparison to analogous metal salts and professional judgment.		
	Immune System Effects	Expected to have a moderate hazard potential for immunotoxicity effects resulting from the presence of bioavailable metal species. (Estimated)	Professional judgment	Estimated based on analogy to confidential metal salts.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		MODERATE: The measured green algae EC ₅₀ is between 10 and 100 mg/L. For fish and <i>Daphnia</i> , adequate toxicity values have not been determined; reported values are not LC ₅₀ but the highest dose tested.		
Fish LC ₅₀		Danio rerio (Zebra fish) 96-hour LC ₅₀ >11 mg/L (Experimental)	NICNAS, 2005	Reported in a secondary source for a commercial formulation.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	<i>Danio rerio</i> (Zebra fish) 96-hour LC ₅₀ >9.2 mg/L (Experimental)	Submitted confidential study	Study reported in a submitted confidential study.
	<i>Danio rerio</i> (Zebra fish) 96-hour LC ₅₀ >100 mg/L (Experimental)	Submitted confidential study	Study reported in a submitted confidential study; Study conducted according to EU Method C.1 (Acute Toxicity for Fish).
Daphnid LC₅₀	<i>Daphnia magna</i> 48-hour LC ₅₀ >33.7 mg/L (Experimental)	NICNAS, 2005	Reported in a secondary source for a commercial formulation.
	<i>Daphnia magna</i> 48-hour LC ₅₀ >33 mg/L (Experimental)	Submitted confidential study	Study reported in a submitted confidential study.
	<i>Daphnia magna</i> 48-hour EC ₅₀ >100 mg/L; 48-hour NOEC = 100 mg/L	Submitted confidential study	Study reported in a submitted confidential study; Study conducted according to OECD Guideline 202 (<i>Daphnia</i> sp. Acute Immobilization Test).
Green Algae EC₅₀	<i>Scenedesmus subspicatus</i> 72-hour E _b C ₅₀ of 60 mg/L (Experimental); <i>Scenedesmus subspicatus</i> 72-hour E _r C ₅₀ of 76 mg/L (Experimental)	NICNAS, 2005	Reported in a secondary source for a commercial formulation.
	72-hour EC ₅₀ = 50mg/L (Experimental)	Submitted confidential study	Study reported in a submitted confidential study.
	<i>Scenedesmus subspicatus</i> 72-hour EC ₅₀ >180 mg/L (Experimental)	Submitted confidential study	Study reported in a submitted confidential study; Study conducted according to EU Method c.3 (Algal Inhibition Test).
Chronic Aquatic Toxicity	MODERATE: An experimental value of 1.8 mg/L was reported for green algae, while measured toxicity values for fish and <i>Daphnia</i> are >10 mg/L.		
Fish ChV	48 mg/L (Estimated)	Submitted confidential study	Study reported in a submitted confidential study.
	<i>Danio rerio</i> (Zebra fish) 28-day NOEC = 100 mg/L; LOEC >100 mg/L (Experimental)	Submitted confidential study	Study reported in a submitted confidential study; Study conducted according to OECD Guideline 215 (Fish, Juvenile Growth Test).

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Aluminum Diethylphosphinate CASRN 225789-38-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Daphnid ChV		<i>Daphnia magna</i> 21-day EC ₅₀ = 22.3 mg/L for immobility (Experimental) <i>Daphnia magna</i> 21-day EC ₅₀ = 46.2 mg/L for reproduction (Experimental) <i>Daphnia magna</i> 21-day LOEC = 32 mg/L for immobility and reproduction (Experimental) <i>Daphnia magna</i> 21-day NOEC = 10 mg/L for immobility and reproduction (Experimental)	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation.
Green Algae ChV		1.8 mg/L (Experimental)	Submitted confidential study	Study reported in a submitted confidential study.
ENVIRONMENTAL FATE				
Transport		Although the behavior of metal salts under environmental conditions is dependent on the characteristics of the local environment (predominately pH), transport of both the metal species and the organic anion is anticipated to be dominated by leaching through soil, runoff to aqueous environments, adsorption and/or precipitation of the metal ion onto soil or sediment, and wet and dry deposition of dust particulates in air to land or surface water. Volatilization of this ionic compound from either wet or dry surfaces is not expected to be an important fate process. Nevertheless, the environmental fate of this organic salt will be dependent on its pH-dependent dissociation, and adequate data are not available.		
	Henry's Law Constant (atm·m³/mole)	<10 ⁻⁸ (Estimated)	Professional judgment	Cutoff value for nonvolatile compounds.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	Approximately 0.38 according to OECD Guideline 121 (Measured)	ECHA, 2013; Submitted confidential study	Guideline study.
	Level III Fugacity Model			This substance is not amenable to the model.

Aluminum Diethylphosphinate CASRN 225789-38-8

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Persistence		HIGH: For the organic counter-ion, estimates indicate that the half-life for ultimate aerobic biodegradation in water is less than 60 days, which converts to moderate potential for persistence. However, the metal ion is recalcitrant to biodegradation or other typical environmental removal processes.		
Water	Aerobic Biodegradation	Organic counter-ion: Days-weeks (primary survey model) Weeks (ultimate survey model) (Estimated)	EPI	
		Metal ion: Recalcitrant (Estimated)	Professional judgment	Metal ions will not degrade in the environment.
		Not readily biodegradable according to OECD Guideline 301 F (Measured)	ECHA, 2013; Submitted confidential study	Guideline study.
		Not inherently biodegradable according to OECD Guideline 302 C (Inherent Biodegradability: Modified MITI Test (II)) (Measured)	ECHA, 2013; Submitted confidential study	Guideline study.
		Not inherently biodegradable (Measured)	Stuer-Lauridsen et al., 2007	Sufficient details were not available to assess the quality of this study.
		Not readily biodegradable (Measured)	NICNAS, 2005	Reported in a secondary source for a commercial formulation.
		Not readily biodegradable (Measured)	Stuer-Lauridsen et al., 2007	Sufficient details were not available to assess the quality of this study.
	Volatilization Half-life for Model River	Not a significant fate process (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	Not a significant fate process (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation	Respiration inhibition of activated sludge microorganisms LC ₅₀ = 1968 mg/L, NOEC = 483 mg/L (Measured)	NICNAS, 2005; Submitted confidential study	Reported in a secondary source for a commercial formulation.
	Anaerobic Biodegradation	No degradation according to ISO/DIS 14853 (Measured)	Stuer-Lauridsen et al., 2007	Guideline study reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	Not a significant fate process (Estimated)	Professional judgment	This chemical is expected to exist entirely in particulate form in air.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	Metal salts form a variety of hydroxylation products as a function of pH. Hydrolysis of the organic counter-ion is not expected to be a significant fate process (Estimated)	Wolfe and Jeffers, 2000; Professional judgment	The organic counter ion does not contain functional groups that would be expected to hydrolyze readily under environmental conditions.
Environmental Half-life		Organic counter-ion: <60 days Metal ion: Recalcitrant (Estimated)	EPI; Professional judgment	Based on estimated biodegradation half-lives for the organic counter-ion and metal ions will not degrade in the environment.
Bioaccumulation		LOW: Aluminum diethylphosphinate is not expected to have potential for bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment	Available data suggests this chemical will dissociate under environmental conditions.
	BAF			No data located.
	Metabolism in fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Aluminum Hydroxide

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

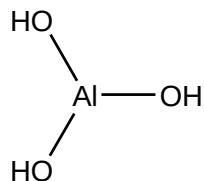
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^R Recalcitrant: Substance is comprised of metallic species that will not degrade, but may change oxidation state or undergo complexation processes under environmental conditions.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Aluminum Hydroxide	21645-51-2	L	<i>L</i>	L	<i>L</i>	L	M	<i>M</i>	L		VL	VL	<i>M</i>	<i>M</i>	<i>H^R</i>	<i>L</i>

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Aluminum Hydroxide



CASRN: 21645-51-2

MW: 78.01

MF: AlH₃O₃

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: O[Al](O)O

Synonyms: Aluminum hydroxide (Al(OH)₃); Aluminum trioxide; Gibbsite; Bayersite; Nordstrandite; Aluminum trihydrate

Chemical Considerations: This alternative is an inorganic compound and in the absence of experimental data, professional judgment using chemical class and structural considerations were used to complete this hazard profile.

Polymeric: No

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: None

Analog: Unspecified analogous aluminum compounds were discussed in the structural based professional judgment rationale.

Endpoint(s) using analog values: Carcinogenicity, reproductive effects, immunotoxicity

Analog Structure: Not applicable

Structural Alerts: Aluminum compounds (EPA, 2010).

Risk Phrases: Not classified by Annex I Directive 67/548/ European Economic Community & IUCLID (Pakalin et al., 2007).

Hazard and Risk Assessments: Risk assessment completed for aluminum hydroxide by the National Research Council Subcommittee on Flame-Retardant Chemicals (NRC, 2000). Hazard assessment completed for Design for the Environment (DfE) Alternatives Assessment for Flame Retardants in Printed Circuit Boards, Review Draft, November 8, 2008 (EPA, 2008).

Aluminum Hydroxide CASRN 21645-51-2			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	Decomposes at approximately 200 (Measured)	European Commission, 2000	Adequate.
	Decomposes at approximately 150-220 to Al ₂ O ₃ and H ₂ O (Measured)	European Commission, 2000	
	Decomposes (loses water) at 300 (Measured)	Lewis, 2000	
Boiling Point (°C)	The substance is expected to decompose before boiling (Estimated)	Professional judgment	Based on the values included in the melting point section of this assessment.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; EPA, 1999	Cutoff value for compounds that are anticipated to be nonvolatile, according to HPV assessment guidance.
Water Solubility (mg/L)	≤0.09 at pH 6-7 Organisation of Economic Cooperation and Development (OECD) Guideline 105 Purity calculated based on aluminum oxide (Measured)	ECHA, 2013	Guideline study reporting non-specific value that is in agreement with other experimental values indicating poor solubility.

Aluminum Hydroxide CASRN 21645-51-2

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	0.0117 to 0.0947 at pH 7.5-8.1 and 21-24°C.	Submitted study	Reported in a nonguideline study done to prepare for toxicity testing.
	Reported as 11.7 to 94.7 µg/L Al(OH) ₃ and 4.06 to 32.75 µg/L Al.		
	100 mg of Al(OH) ₃ was dissolved in 100 mL distilled water or test media prepared according to OECD 201, 202 or 211, filtered, and then analyzed using Graphite Furnace Atomic Absorption Spectrometry (GF AAS) and Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). (Measured)		
	1.5 at 20°C at pH 7 (Measured)		
	1.5x10 ⁻² at 20 °C at pH 8-9 (Measured)		
	Insoluble in water (Estimated)	Lide, 2006	Measured values were not consistently reported, but are sufficient for subsequent components of the hazard assessment.
	Practically insoluble in water (Estimated)	O'Neil, 2001; Lewis, 2000	
Log K_{ow}			No data located. This inorganic compound is not amenable to available estimation methods.
Flammability (Flash Point)	Not flammable (Estimated)	European Commission, 2000	Adequate.
Explosivity	Not explosive (Estimated)	European Commission, 2000	Adequate.
Pyrolysis			No data located.
pH	pH of a saturated solution in water was 6 to 7 (Measured)	ECHA, 2013	Determined in a water solubility study.
pK_a	Not applicable (Estimated)	Professional judgment	Determination of dissociation constant is not possible due to the insolubility of the test substance.

Aluminum Hydroxide CASRN 21645-51-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		Toxicokinetic data suggest that aluminum hydroxide is not readily absorbed in humans following oral exposure. Excretion occurs primarily through feces, and less so in urine. Animal studies indicated that aluminum accumulated in intestinal cells but was not found in other tissues.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	²⁶ Al labeled aluminum hydroxide (in water suspension) was administered to rats by oral gavage. The mean fractional uptake of ²⁶ Al from aluminum hydroxide was 0.025±0.041% compared to a mean fractional uptake of 0.079±0.0057% from ²⁶ Al labeled aluminum citrate in solution. Aluminum hydroxide as an insoluble compound is less bioavailable than soluble compounds.	ECHA, 2013	Reported in a secondary source. Adequate, performed in accordance with OECD guidelines and good laboratory practice (GLP); Aluminium hydroxide, was suspended in water with added 1% carboxymethylcellulose (to maintain a suspension).
		After rats were exposed to aluminum hydroxide in drinking water for 10 weeks, aluminum accumulated in intestinal cells but not in other tissues.	HSDB, 2013	Reported in a secondary source, study details and test conditions were not provided.
		In metabolic studies in humans, 12% of an oral load of aluminum hydroxide was retained, but absorption was not calculated.	HSDB, 2013	Reported in a secondary source, study details and test conditions were not provided.
		The absorbed fraction of aluminum hydroxide in two human males dosed orally was 0.01%.	HSDB, 2013	Reported in a secondary source, study details and test conditions were not provided.
		Adult humans with renal failure who ingested 1.5–3.0 g aluminum hydroxide per day for 20-32 days absorbed between 100 and 568 mg aluminum per day (7-19% of the dose).	HSDB, 2013	Reported in a secondary source, study details and test conditions were not provided.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Adult humans taking aluminum antacids had a 3-fold increase of aluminum levels in the urine; minimal aluminum was absorbed and was mostly excreted in the feces.	ATSDR, 2008	Reported in a secondary source, study details were not provided.
Acute Mammalian Toxicity		LOW: Aluminum hydroxide has low acute toxicity based on oral LD ₅₀ >2,000 mg/kg-bw in rats.		
Acute Lethality	Oral	Rat oral LD ₅₀ >5,000 mg/kg bw	European Commission, 2000	Reported in a secondary source, study details and test conditions were not provided.
		Rat oral LD ₅₀ >2,000 mg/kg bw	ECHA, 2013	Reported in a secondary source. Performed in accordance with OECD guidelines and GLP.
	Dermal			No data located.
	Inhalation			No data located.
Carcinogenicity		LOW: Aluminum hydroxide is estimated to be of low hazard for carcinogenicity based on professional judgment and comparison to analogous aluminum compounds.		
	OncoLogic Results	Low potential for carcinogenicity (Estimated)	Professional judgment	Estimated based on professional judgment and comparison to analogous aluminum compounds.
	Carcinogenicity (Rat and Mouse)			
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: Aluminum hydroxide did not cause mutations in bacteria <i>in vitro</i> and did not cause chromosomal aberrations <i>in vitro</i> .		
	Gene Mutation <i>in vitro</i>	Negative in mouse lymphoma cells with and without metabolic activation	ECHA, 2013	Adequate, performed in accordance with OECD guidelines and GLP.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>			No data located.
	Chromosomal Aberrations <i>in vivo</i>	Negative for induction of micronuclei in polychromatic erythrocytes of bone marrow in Sprague-Dawley rats	ECHA, 2013	Adequate, performed in accordance with OECD guidelines and GLP.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: Aluminum hydroxide is estimated to be of low hazard for reproductive effects based on professional judgment and comparison to analogous aluminum compounds.		
	Reproduction/ Developmental Toxicity Screen	Low potential for reproductive effects (Estimated)	Professional judgment	Estimated based on professional judgment and comparison to analogous aluminum compounds.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		LOW: Aluminum hydroxide does not show developmental toxicity when administered orally to rats or mice at dose levels up to 266 mg/kg-day. There were no data located regarding developmental neurotoxicity.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development	Low potential for developmental neurotoxicity (Estimated)	Professional judgment	Estimated based on analogy to structurally similar compounds.
		Mouse, oral, no developmental effects, NOAEL = 266 mg/kg-day (highest dose tested)	Domingo et al., 1989	Adequate.

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Aluminum Hydroxide CASRN 21645-51-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Mouse, oral, NOAEL = 268 mg/kg-day (highest dose tested)	Gomez et al., 1989	Abstract only.
		Mouse, oral, NOAEL = 300 mg/kg-day (only dose tested)	Colomina et al., 1994	Abstract only.
		Rat, oral, NOAEL = 768 mg/kg-day (highest dose tested)	Gomez et al., 1990	Abstract only.
		Rat, oral, NOAEL = 384 mg/kg-day (only dose tested)	Llobet et al., 1990	Abstract only.
	Postnatal Development			No data located.
Neurotoxicity		MODERATE: Aluminum hydroxide is expected to be of moderate hazard for neurotoxicity based on impaired learning in a labyrinth maze test in a 90-day oral study in rats at 35 mg Al/kg/day as aluminum hydroxide with citric acid. Impaired learning in a labyrinth maze test was also reported in rats orally exposed to 300 mg Al/kg/day as aluminum hydroxide; there is uncertainty in the threshold of response, the possibility that effects occur at doses <100 mg/kg/day (in the Moderate - High hazard designation range) cannot be ruled out.		
	Neurotoxicity Screening Battery (Adult)	30-day Rat, oral diet, no significant effects noted, NOAEL = 1,252 mg Al/kg-day	Thorne et al. 1986, 1987 (as described in ATSDR, 2008)	Reported in a secondary source.
		90-day Rat, oral gavage, impaired learning in a labyrinth maze test NOAEL = Not established LOAEL = 35 mg Al/kg-day as aluminum hydroxide with citric acid (only dose tested)	Bilkei-Gorzo, 1993 (as described in ATSDR, 2008)	Reported in a secondary source; dose reported as 35 mg/kg-day as aluminum hydroxide with citric acid; citric acid was added to increase absorption; it is not proven that negative effects only related to aluminum hydroxide and not based on citric acid; also, the background aluminum content of the diet fed to rats was not reported; only one dose tested.
		90-day Rat, oral gavage, impaired learning in a labyrinth maze test NOAEL = Not established LOAEL = 300 mg Al/kg-day as aluminum hydroxide (only dose tested)	Bilkei-Gorzo, 1993	The background aluminum content of the diet fed to rats was not reported; only one dose tested; study description lacks sufficient details on individual results.

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Aluminum Hydroxide CASRN 21645-51-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects		MODERATE: Aluminum hydroxide is estimated to have potential for immunotoxicity based on professional judgment and comparison to analogous aluminum compounds. Aluminum hydroxide is of low hazard for repeated dose effects based on an experimental study indicating no adverse effects in rats following oral doses up to 14,470 ppm (302 mg/kg-day). In addition, a low potential for repeated dose effect is estimated based on professional judgment and comparison to analogous aluminum compounds.		
		Low potential for repeated dose effects but moderate potential for immunotoxicity. (Estimated)	Professional judgment	Estimated based on professional judgment and comparison to analogous aluminum compounds.
		28-day Rat (male), oral diet, no systemic effects noted. NOAEL = 14,470 ppm/diet (302 mg Al/kg-day)	Hicks et al., 1987	Study details from primary source.
		6-Week human, oral, LOAEL = 25 mg Al/kg-day (Reduction in primed cytotoxic T-cells, only dose tested)	ATSDR, 2008	Reported in a secondary source.
Skin Sensitization		LOW: Aluminum hydroxide is not a skin sensitizer in guinea pigs.		
	Skin Sensitization	Low potential for skin sensitization (Estimated)	Professional judgment	Estimated based on professional judgment and comparison to analogous aluminum compounds.
		Not sensitizing to guinea pigs in an <i>in vivo</i> maximization test	ECHA, 2013	Reported in a secondary source; conducted in accordance with OECD guidelines and GLP.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		VERY LOW: Aluminum hydroxide is not irritating to rabbit eyes.		
	Eye Irritation	Not irritating, rabbits	ECHA, 2013	Reported in a secondary source; Conducted in accordance with OECD guidelines and GLP.

Aluminum Hydroxide CASRN 21645-51-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Dermal Irritation		VERY LOW: Aluminum hydroxide is not irritating to skin.		
Dermal Irritation		Not irritating, rabbits	ECHA, 2013	Reported in a secondary source. Conducted in accordance with OECD guidelines and GLP.
		Not irritating, rabbits, mice and pigs	ECHA, 2013	Reported in a secondary source; nonguideline studies.
Endocrine Activity		No data located.		
				No data located.
Immunotoxicity		Aluminum hydroxide is estimated to have potential for immunotoxicity based on professional judgment and comparison to analogous aluminum compounds.		
	Immune System Effects	Moderate potential for immunotoxicity (Estimated)	Professional judgment	Estimated based on professional judgment and comparison to analogous aluminum compounds.
		6-Week human, oral LOAEL = 25 mg Al/kg-day (Reduction in primed cytotoxic T-cells, only dose tested)	ATSDR, 2008	Reported in a secondary source.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		MODERATE: Aluminum hydroxide is estimated to be of moderate hazard for acute aquatic toxicity based on potential for dissolved aluminum species to cause adverse effects in aquatic species, as described in the EPA New Chemical Categories document which includes inorganic salts of aluminum (Professional judgment; EPA, 2010). Additional studies for acute toxicity to daphnia and algae are ongoing; the results of these studies may affect the acute aquatic hazard designation.		
Fish LC ₅₀		Salmo trutta 96-hour NOEC >100 mg/L (Experimental)	European Commission, 2000	Reported in a secondary source. The effect concentration is greater than the measured water solubility.
Daphnid LC50		Daphnia magna 48-hour NOEC >100 mg/L (Experimental)	European Commission, 2000	Reported in a secondary source. Study details and test conditions were not available and the effect concentration is greater than the measured water solubility.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	<i>Daphnia magna</i> 48-hour NOEC >0.135 mg/L (Experimental)	ECHA, 2013	Study conducted with aluminum powder.
	<i>Daphnia magna</i> 48-hr EC50 = 0.8240 mg/L (Experimental)	TSCATS, 1996	Study incorrectly cited in source; results are for a different test substance, vanadium hydroxide oxide.
Green Algae EC50	<i>Selenastrum capricornutum</i> 72-hour NOEC >100 mg/L (Experimental)	European Commission, 2000	Reported in a secondary source. The effect concentration is greater than the measured water solubility.
	<i>Selenastrum capricornutum</i> 96-hr EC50 = 0.6560 mg/L (Experimental)	TSCATS, 1996	Study incorrectly cited in source; results are for a different test substance, vanadium hydroxide oxide.
	<i>Pseudokirchnerella subcapitata</i> 96-hr EC50 = 0.46 mg/L (Experimental)	ECHA, 2013	Reported in a secondary source. EC ₅₀ range: 0.57 mg/L at pH of 7.6 and 0.46 mg/L at pH of 8.2. The water solubility of aluminum hydroxide under basic pH conditions is not available; experimental details are not sufficient to address the confidence limits of these data points.
	<i>Pseudokirchnerella subcapitata</i> 72-hour NOEC = 0.004 – 0.052 mg/L (Experimental)	ECHA, 2013	Reported in a secondary source. DfE criteria are based on LC and EC ₅₀ values; therefore a NOEC value is not sufficient to determine a hazard designation.
Chronic Aquatic Toxicity	MODERATE: Aluminum hydroxide is estimated to be of moderate hazard for chronic aquatic toxicity based on potential for dissolved aluminum species to cause adverse effects in aquatic species, as described in the EPA Chemical Categories document which includes inorganic salts of aluminum (Professional judgment; EPA, 2010). An additional study for chronic toxicity to daphnia is ongoing; the results of this study may affect the chronic aquatic hazard designation.		

Aluminum Hydroxide CASRN 21645-51-2

Aluminum Hydroxide CASRN 21645-51-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Fish ChV		<i>Pimephales promelas</i> 42-day NOEC = 0.102 mg/L, LOEC = 0.209 mg/L (Experimental)	TSCATS, 1996	Study incorrectly cited in source; results are for a different test substance, vanadium hydroxide oxide.
Daphnid ChV		<i>Daphnia magna</i> 21-day NOEC = 0.091 mg/L, LOEC = 0.197 mg/L (Experimental)	TSCATS, 1996	Study incorrectly cited in source; results are for a different test substance, vanadium hydroxide oxide.
Green Algae ChV				No data located.
ENVIRONMENTAL FATE				
Transport		Although the behavior of aluminum salts under environmental conditions is dependent on the characteristics of the local environment (predominately pH), transport of the aluminum (III) species is anticipated to be dominated by leaching through soil; runoff to aqueous environments; adsorption and/or precipitation of the metal ion onto soil or sediment; and wet and dry deposition dust particulates in air to land or surface water. Volatilization of this ionic compound from either wet or dry surfaces is not expected to be an important fate process. Under acidic pHs typically encountered in the environment, it may form insoluble polymeric aluminum hydroxide colloids while under basic conditions; anionic aluminum hydroxide is expected to predominate. Other factors influencing its behavior include the presence of dissolved organic matter, the extent of absorption on suspended particles, and the presence of other aluminum species.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment	Cutoff value for non-volatile compounds.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	Professional judgment; EPA, 2004	Cutoff value for non-mobile compounds.
	Level III Fugacity Model			No data located.
Persistence		HIGH: As an inorganic material, aluminum hydroxide is not expected to biodegrade or oxidize under typical environmental conditions. Aluminum hydroxide does not absorb light at environmentally relevant wavelengths and is not expected to photolyze. No degradation processes for aluminum hydroxide under typical environmental conditions were identified.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	Substance is or contains inorganic elements, such as metal ions or oxides, that are expected to be found in the environment >180 days after release.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law constant.
Soil	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	Substance contains inorganic elements.
	Anaerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	Substance contains inorganic elements.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	>1 year (Estimated)	Professional judgment	Substance contains inorganic elements.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Professional judgment	Aluminum hydroxide does not absorb UV light at environmentally relevant wavelengths and is not expected to undergo photolysis.
	Hydrolysis			Dissociation of aluminum hydroxide in environmental waters is dependent both on the pH and the local concentration of other aluminum species; dissociation will not occur unless in highly acidic waters, e.g., pH 3.

Aluminum Hydroxide CASRN 21645-51-2			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Environmental Half-Life			No data located. Inorganic compounds are outside the estimation domain (EPI).
Bioaccumulation	LOW: Aluminum hydroxide is not expected to bioaccumulate.		
	Fish BCF	<100 (Estimated)	Professional judgment
	BAF	<100 (Estimated)	Professional judgment
	Metabolism in Fish		No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING			
Environmental Monitoring	No data located.		
Ecological Biomonitoring	No data located.		
Human Biomonitoring	This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Ammonium Polyphosphate

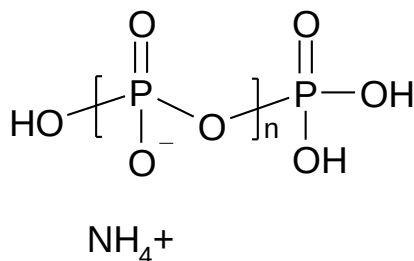
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment. ^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Ammonium Polyphosphate	68333-79-9	L	L	L	L	L	L	L ^d	L		VL	L	L	L	VH	L

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Ammonium Polyphosphate



CASRN: 68333-79-9

MW: ~100,000

MF: (NH₄)_k·H_(n+2-k)P_nO_(3n+1) (NAS, 2000)

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: This polymer inorganic salt with MW >1,000 and no low MW components is not amenable to SMILES notation.

Synonyms: Polyphosphoric acids, ammonium salts; APPII; AP 422; AP 462; APP (fireproofing agent); APP 422; Albaplas AP 95; Amgard CL; Amgard MC; Amgard TR; Ammonium polyphosphate; Ammonium polyphosphates; Antiblaze MC; Antiblaze MCM; Budit 3076; Budit 3076DC; Budit 3077; Budit 365; DFP-I; EINECS 269- 789-9; Exolit 462; Exolit 263; Exolit 422; Exolit 442; Exolit 454; Exolit 455; Exolit 462; Exolit 470; Exolit AP 422; Exolit AP 423; Exolit AP 462; FR-Cros 480; FR-Cros 484; Fire-Trol LCG-R; Flameguard PT 8; Hostaflam 423; Hostaflam AP 420; Hostaflam AP 422; Hostaflam AP 462; Hostaflam AP 464; Hostaflam TP-AP 751; Hostaflam TP-AP 752; Novawhite; Phos-Chek P 30; Phos-Chek P 40; Phos-Chek P 60; Poly-N 10-34-0; Poly-N 11-37-0; Polymetaphosphoric acid, ammonium salt; Polyphosphoric acid, ammonium salt; Sumisafe; Taien A; Taien H

Chemical Considerations: High-MW ammonium polyphosphate (n>50) with a minimum of water-soluble fractions are being used to an increasing extent in flame retardants (Gard, 2005, Schrödter et al., 2005). These insoluble ammonium polyphosphates are long chain, ionic phosphate polymers with the following MF: (NH₄)_k·H_(n+2-k)P_nO_(3n+1), where n typically can range from 70 (Wanjie International Co., 2007) to >1,000 (PINFA, 2010) and k represents the degree of replacement of hydrogen ions with ammonium ions. MWs can be as high as 100,000 g/mole and oligomers with a MW <1,000 are not expected. The high MW inorganic polymer was assessed as a non-bioavailable material. Prior assessments for similar polyphosphates evaluated the lower, water soluble moieties, which also have application as a flame retardant.

Polymeric: Yes

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: Ammonia; phosphate (Leisewitz et al., 2000)

Analog: No analogs

Endpoint(s) using analog values: Not applicable

Analog Structure: Not applicable

Structural Alerts: Not applicable

Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community & IUCLID (Pakalin et al., 2007).

Hazard and Risk Assessments: The Maine Department of Environmental Protection (MDEP) Safer Alternative Assessment for Decabromodiphenyl Ether Flame Retardant in Plastic Pallets includes a Green Screen Assessment of Ammonium Polyphosphate (MDEP, 2007) although this was performed on lower MW materials.

Ammonium Polyphosphate CASRN 68333-79-9			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	Decomposes at > 275°C (Measured)	IUCLID, 2000	Consistent with values reported in other secondary sources.
	Decomposes at 300°C for long chain ammonium polyphosphate (Measured)	OECD SIDS, 2007	Consistent with values reported in other secondary sources.
	Decomposes at approx. 150°C for short chain ammonium polyphosphate (Measured)	OECD SIDS, 2007	Reported for the low MW ammonium polyphosphate.
Boiling Point (°C)	>275, decomposition with evolution of ammonia and phosphoric acid (Measured)	Clariant, 2011	Reported in chemical datasheet, consistent with the high melting point expected for this chemical.
Vapor Pressure (mm Hg)	<10 ⁻⁸ at 25°C (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large high MW polymers.
	<0.75 at 20°C reported as < 1 hPa (Measured)	IUCLID, 2000; OECD SIDS, 2007	Ammonium polyphosphate will have negligible vapor pressure as an inorganic salt. Any measurable vapor pressure is due to decomposition and the release of ammonia gas.
Water Solubility (mg/L)	0.5% (w/w) at 25°C in 10% suspension (Measured)	Clariant, 2011	Reported in chemical datasheet.
	0.5-0.05% max. at 25°C in 10% suspension (Measured)	Wanjie International Co., 2007	Inadequate. This value likely represents a dispersion and is not an indication of the material's true water solubility.
Log K_{ow}			No data located; polymers with a MW >1,000 are outside the domain of the available estimation methods.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.

Ammonium Polyphosphate CASRN 68333-79-9			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Pyrolysis			No data located.
pH	5.5-7.5 at 25°C in 10% suspension (Measured)	Clariant, 2011	Measured by chemical supplier. Data are likely for the formulated material in water, and would be dependent on the ammonium/polyphosphate ratios.
pK _a			No data located.

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		Absorption is not expected for any route of exposure. This inorganic polymer moiety is large with a MW >1,000. Based on professional judgment, it is expected to have limited bioavailability and therefore is not expected to be readily absorbed, distributed or metabolized in the body.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Gastrointestinal absorption of higher polyphosphates following ingestion is probably low; they are most likely hydrolyzed by stomach acids to phosphate and ammonium ions.	NAS, 2000	Limited study details reported in a secondary source.
	Other	No absorption is expected for all routes of exposure if insoluble in water (Estimated)	Professional judgment	Estimated based on physical/chemical properties and limited bioavailability.
Acute Mammalian Toxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore is of low potential for acute mammalian toxicity. This low hazard designation is also supported by a rat oral median lethal dose (LD₅₀) of >2,000 mg/kg, a rat dermal LD₅₀ of >2,000 mg/kg, and a 4-hour rat median lethal concentration (LC₅₀) of >5.09 mg/L.		
Acute Lethality	Oral	Rat oral LD ₅₀ >2,000 mg/kg	UNEP, 2008	Although limited study details were reported in a secondary source, results indicated that LD ₅₀ values were greater than the high dosages tested.
		Rat oral LD ₅₀ = 4,740 mg/kg	IUCLID, 2000; Clariant, 2009	Although limited study details were reported in a secondary source, results indicated that LD ₅₀ values were greater than the high dosages tested; data for commercial mixture Exolit 422 (purity not specified).
		Rabbit oral LD ₅₀ >2,000 mg/kg	UNEP, 2008	Although limited study details were reported in a secondary source, results indicated that LD ₅₀ values were greater than the high dosages tested.

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Dermal	Rat dermal LD ₅₀ >5,000 mg/kg	IUCLID, 2000; UNEP, 2008	Although limited study details were reported in a secondary source, results indicated that LD ₅₀ values were greater than the high dosages tested; data for commercial mixture Exolit 456 (90% ammonium polyphosphate and 10% monoammonium phosphate).
		Rat dermal LD ₅₀ >2,000 mg/kg	UNEP, 2008	Although limited study details were reported in a secondary source, results indicated that LD ₅₀ values were greater than the high dosages tested.
	Inhalation	Rat Inhalation 4-hour LC ₅₀ >5.09 mg/L	UNEP, 2008	Although limited study details were reported in a secondary source, results indicate that LC ₅₀ values are greater than the highest concentration tested; it is unspecified if the inhaled substance is a vapor/gas or dust/mist/fume.
Carcinogenicity		LOW: This polymer is large, with a MW >1,000. It is expected to have few to no residual monomers. Additionally, crosslinking, swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected. Therefore, there is low potential for carcinogenicity based on professional judgment. No data located.		
	OncoLogic Results	Limited bioavailability expected; crosslinking swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected. (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large high MW polymers.
	Carcinogenicity (Rat and Mouse)			
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for genotoxicity.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large high MW polymers.

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Negative, Ames assay, <i>Salmonella Typhimurium</i> TA98, TA100, TA1535, TA1537, TA1538, and <i>E. coli</i> WP2uvrA; with and without metabolic activation	ESIS, 2000	Reported in a secondary source, study details and test conditions were not provided.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>			No data located.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for reproductive effects based on professional judgment and the polymer assessment literature. No data located.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Developmental Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for developmental effects based on professional judgment and the polymer assessment literature. No data located.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for neurotoxicity based on professional judgment and the polymer assessment literature. No data located.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW _n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations. No experimental data located.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
		This polymer MW _n is >10,000; There is uncertain potential for lung effects from lung overload if respirable particles are inhaled; Polymers with a MW >10,000 have the potential for irreversible lung damage as a result of lung overloading. (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Skin Sensitization		LOW: Not a skin sensitizer in guinea pigs.		
	Skin Sensitization	Not a skin sensitizer, guinea pigs	Safepharm, 1993 (as described in NAS, 2000)	Reported in chemical data sheet; adequate study details provided.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		VERY LOW: Mixtures containing primarily ammonium polyphosphate were not irritating to rabbit eyes.		
	Eye Irritation	Not irritating, rabbits	UNEP, 2008	Reported in secondary source; study details and test conditions were not provided; data for commercial mixture (70% ammonium polyphosphate and 30% monoammonium phosphate).
		Not irritating, rabbits	ESIS, 2000	Reported in a secondary source; study details and test conditions were not provided; data for commercial mixture Exolit 456 (90% ammonium polyphosphate and 10% monoammonium phosphate). Study in accordance with Organisation of Economic Cooperation and Development (OECD) 405 guideline.
Dermal Irritation		LOW: Mixtures containing primarily ammonium polyphosphate were not irritating to slightly irritating to skin of rabbits.		
	Dermal Irritation	Not irritating, rabbits 4-hour occlusion	UNEP, 2008	Reported in a secondary source; study details and test conditions were not provided; data for commercial mixture (70% ammonium polyphosphate and 30% monoammonium phosphate).

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Slightly irritating, rabbits; 24-hour occlusive patch test	ESIS, 2000; IUCLID, 2000	Reported in a secondary source; study details and test conditions were not provided; data for commercial mixture Exolit 422 (purity not specified).
		Not irritating	ESIS, 2000; IUCLID, 2000	Reported in a secondary source; study details and test conditions were not provided; data for commercial mixture Exolit 456 (90% ammonium polyphosphate and 10% monoammonium phosphate). Study in accordance with OECD 404 guideline.
		Not irritating, rabbits. Very slight erythema in 2/3 animals 1-hour after exposure to AMGARD LR4; however, no skin reaction was observed after 24 and 72 hours.	NAS, 2000	Limited study details reported in a secondary source. Study was conducted using AMGARD LR2 (liquid containing test substance, urea and water) and AMGARD L4 (powder).
		Not irritating, rabbits exposed 5 times (23 hours for each exposure) to fabric treated with LR2	NAS, 2000	Limited study details reported in a secondary source. Study was conducted using AMGARD LR2 (liquid containing test substance, urea and water).
		Not irritating, human volunteers	NAS, 2000	Limited study details reported in a secondary source. Study was conducted using AMGARD LR2 (liquid containing test substance, urea and water).
Endocrine Activity		This polymer is large, with a MW >1,000. It is not expected to have endocrine activity due to its poor bioavailability and inability to be readily metabolized in the body based on professional judgment.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Immunotoxicity		This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for immunotoxicity based on professional judgment and the polymer assessment literature. No data located.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Water insoluble polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to have no effects at saturation (NES). These polymers have NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Based on professional judgment, guidance for the assessment of aquatic toxicity hazard leads to a low potential for hazard for those materials that display NES. Experimental data are also consistent with this hazard designation.		
Fish LC ₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
		<i>Oncorhynchus mykiss</i> 96-hour LC ₅₀ >101 mg/L (Experimental)	IUCLID, 2000; UNEP, 2008	Inadequate; limited study details reported in a secondary source and value is much greater than the anticipated water solubility.
		<i>Danio rerio</i> 96-hour LC ₅₀ = 100 – 1,000 mg/L (Experimental)	Clariant, 2009	Inadequate; limited study details reported in a secondary source and value is much greater than the anticipated water solubility.
		<i>Brachydanio rerio</i> 96-hour LC ₅₀ >500 mg/L (Experimental)	IUCLID, 2000	Guideline study red in a secondary source with limited study details; OECD 203. Test substance: Exolit 456 (90% ammonium polyphosphate and 10% of ammonium phosphate).

Ammonium Polyphosphate CASRN 68333-79-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Freshwater fish (<i>Oncorhynchus mykiss</i>) 96-hour LC ₅₀ = 123,000 – 1,326,000 µg/L (123 – 1,326 mg/L) (Experimental)	ECOTOX	Limited study details reported in a secondary source.
	Freshwater fish (<i>Oncorhynchus tshawytscha</i>) 96-hour LC ₅₀ = 685 – 1,195 mg/L (Experimental)	Buhl and Hamilton, 1998	Limited study details reported in a secondary source. Study conducted with Fire-Trol LCG-R (composed primarily of liquid ammonium polyphosphate with attapulgate clay, a corrosion inhibitor and iron oxide).
	Freshwater fish (<i>Oncorhynchus mykiss</i>) LC ₅₀ = 872 – >10,000 mg/L (Experimental)	Gaikowski et al., 1996	Limited study details reported in a secondary source. Study conducted with Fire-Trol LCG-R (composed primarily of liquid ammonium polyphosphate with attapulgate clay, a corrosion inhibitor and iron oxide).
	Freshwater fish (<i>Oncorhynchus mykiss</i>) 96-hour LC ₅₀ = 1,006,000 – 10,000,000 µg/L (1,006 – 10,000 mg/L) (Experimental)	ECOTOX	Limited study details reported in a secondary source.
	Freshwater fish (<i>Pimephales promelas</i>) 96-hour LC ₅₀ = 519,000 – 2,317,000 µg/L (519 – 1,080 mg/L) (Experimental)	ECOTOX	Limited study details reported in a secondary source.

Ammonium Polyphosphate CASRN 68333-79-9			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid LC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
	<i>Hyalella azteca</i> 96-hour LC ₅₀ = 73 mg/L (Experimental)	McDonald et al., 1997	Limited study details reported in a secondary source. Study conducted with Fire-Trol LCG-R (composed primarily of liquid ammonium polyphosphate with attapulgite clay, a corrosion inhibitor and iron oxide).
	<i>Daphnia magna</i> 48-hour EC ₅₀ = 90,890 µg/L (90.89 mg/L) (Experimental)	ECOTOX	Limited study details provided in a secondary source.
	<i>Daphnia magna</i> 48-hour EC ₅₀ = 848,000 – 1,036,000 µg/L (848 – 1,036 mg/L) (Experimental)	ECOTOX	Limited study details reported in a secondary source.
	<i>Daphnia magna</i> 24-hour EC ₅₀ = 1,007,000 – 1,976,000 (1,007 – 1,676 mg/L) (Experimental)	ECOTOX	Limited study details reported in a secondary source.
Green Algae EC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity	LOW: Water insoluble polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to have NES. These polymers have NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Based on professional judgment, guidance for the assessment of aquatic toxicity hazard leads to a low potential for those materials that display NES.		

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Fish ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that this ionic polymer is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of $<10^{-8}$ atm-m ³ /mole indicates that it is not expected to volatilize from water to the atmosphere. The estimated K _{oc} of >30,000 indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large high MW polymers.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to adsorb strongly to soil and sediment.
	Level III Fugacity Model			This substance is not amenable to the model.

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Persistence		VERY HIGH: This polymer is large, with a MW >1,000. It is expected to have negligible water solubility and poor bioavailability to microorganisms indicating that biodegradation is not expected to be an important removal process in the environment. Hydrolysis is expected for ammonium polyphosphates, mainly via end-clipping of a monophosphate unit to form monoammonium phosphate. Hydrolysis rates increase with increasing chain lengths, but reach a limit when n>50. Qualitative statements from manufacturers indicate hydrolysis is slow, but increases with prolonged exposure to water and elevated temperatures. Therefore, hydrolysis is not expected to occur at a rate that would greatly reduce the polymeric chain. Furthermore, long-chain ammonium polyphosphates produced for flame retardant applications may be formulated with melamine or other stabilizers that impede hydrolysis. The polymer does not contain functional groups that would be expected to absorb light at environmentally-relevant wavelengths. Evaluation of these degradation values suggest a half-life for the polymer is >180 days.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large high MW polymers.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by microbial populations; therefore, biodegradation is not expected.
		The half-life values ranged from 5.2-8.7 days in soil under aerobic conditions for liquid ammonium polyphosphate. Liquid ammonium polyphosphate hydrolyzed faster than solid ammonium polyphosphate and anaerobic conditions, caused by subsequent flooding, accelerated hydrolysis. (Measured)	OECD SIDS, 2007	Not applicable; this non-guideline study is for the low MW, liquid form of ammonium polyphosphate.

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Study results: None/not reported Test method: Field Test Ammonium polyphosphate breaks down to ammonia and phosphate rapidly in soil and sewage sludge. (Measured)	Leisewitz et al., 2000	Not applicable; biodegradation data is expected for the more soluble low MW ammonium polyphosphate. Reported in a secondary source.
	Anaerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by microbial populations; therefore, biodegradation is not expected.
		Polyphosphate hydrolyzed faster than solid ammonium polyphosphate and anaerobic conditions, caused by flooding, accelerated hydrolysis. (Measured)	OECD SIDS, 2007	Not applicable; this non-guideline study is for the liquid form of ammonium polyphosphate.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	Not a significant fate process (Estimated)	Professional judgment	This substance is expected to exist entirely in particulate form in air and is not anticipated to undergo gas-phase chemical reactions.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.

Ammonium Polyphosphate CASRN 68333-79-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Hydrolysis	Not a significant fate process (Estimated)	Gard, 2005; Wanjie International Co., 2007; PINFA, 2010; EFRA, 2011; Professional judgment	Hydrolysis is expected, mainly via end-clipping of a monophosphate unit to form monoammonium phosphate. Qualitative statements from manufacturers indicate hydrolysis is slow, but increases with prolonged exposure to water and elevated temperatures. Hydrolysis is not expected to occur at a rate that would greatly reduce the polymeric chain to a MW <1,000 g/mole.
		Chemical hydrolysis of polyphosphates proceeds slowly in sterile, neutral solutions at room temperature. Solubility is pH dependent: at pH > 7 the substance will completely hydrolyze to HPO ₄ ²⁻ and at pH 4-7 the substance will completely hydrolyze to H ₂ PO ₄ ⁻ . (Measured)	OECD SIDS, 2007	Consistent with values reported in other secondary sources.
Environmental Half-life		>180 days (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to be removed by other degradative processes under environmental conditions because of limited water solubility and limited partitioning to air.

Ammonium Polyphosphate CASRN 68333-79-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Bioaccumulation		LOW: This ionic polymer is large, with a MW >1,000. It is expected to have negligible water solubility and poor bioavailability indicating that it will have low potential for bioaccumulation based on professional judgment.		
	Fish BCF	<100 (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by aquatic organisms; therefore, bioconcentration is not expected.
	BAF			No data located.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Antimony Trioxide

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^R Recalcitrant: Substance is comprised of metallic species that will not degrade, but may change oxidation state or undergo complexation processes under environmental conditions.

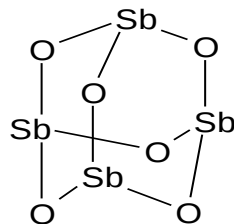
* Ongoing studies may result in a change in this endpoint.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity **		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Antimony Trioxide ¹	1309-64-4	L	M*	M	M	L	L	H	L		L	M	H	M	H ^R	L

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

¹ This compound is included in the ongoing EPA Work Plan evaluation for Antimony Trioxide.

Antimony Trioxide



Representative Structure

CASRN: 1309-64-4

MW: 291.5

MF: Sb₂O₃ (Empirical)

Physical Forms:

Neat: Solid

Use: Flame retardant synergist

SMILES: O=[Sb]O[Sb]=O (Empirical)

Synonyms: Antimony oxide; Antimony white; Antimony (III) oxide; Antimonious oxide; Antimony sesquioxide; C.I. Pigment White 11; Diantimony trioxide; Patox C; Thermoguard B; Timonox; Timonox White Star; Flowers of antimony; Exitelite; Senarmonite; Valentinite; Weiss-piessglanz

Chemical Considerations: This alternative is an inorganic compound. In the absence of experimental data, professional judgment using chemical class and structural considerations were used to complete this hazard profile.

Polymeric: No

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: None

Analog: Confidential antimony-containing salts and compounds

Endpoint(s) using analog values: neurological toxicity

Analog Structure: The analogs are confidential and cannot be suitably represented here.

Structural Alerts: None

Risk Phrases: R40: Limited evidence of a carcinogenic effect (EU RAR, 2008) and H351: Suspected of causing cancer by inhalation (ESIS, 2012).

Hazard and Risk Assessments: Risk assessments completed for antimony trioxide by the European Union in 2008 (EU RAR, 2008) and the Subcommittee on Flame-Retardant Chemicals (NRC, 2000).

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	656 (Measured)	ICSC, 2005	Adequate; measured in the absence of oxygen.
	655 (Measured)	OECD SIDS, 2008	
	655 for the mineral valentinite 570 for the mineral senarmontite (Measured)	Lide, 2008	
Boiling Point (°C)	1,425 (Measured)	ICSC, 2005; Lide, 2008; O'Neil, 2011	Adequate; decomposes on heating.
	1,550 (Measured)	ATSDR, 1992; ICSC, 2005; OECD SIDS, 2008	Reported as sublimation temperature.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; 1999	Cutoff value for compounds that are anticipated to be non-volatile
	1 mm Hg at 574°C (Measured)	Sax, 1979; EU RAR, 2008	Value measured at a nonstandard temperature. Result consistent with a vapor pressure below criteria cutoffs.
Water Solubility (mg/L)	14 at 30°C (Measured)	ICSC, 2005	Water solubility of antimony trioxide is pH dependent; pH for this measurement not provided.
	20 at pH 5; 30 at pH 9 (Measured)	UBA, 2001	Reported values, which span a relatively narrow range, are consistently reported in secondary sources.
	19.7 at pH 5; 25.6 at pH 7; 28.7 at pH 9 Ten grams of the Sb ₂ O ₃ was mixed with 100 mL distilled water; agitated for 24 hours at 20°C, filtered and analyzed using atomic absorption. (Measured)	EU RAR, 2008	

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	2.76 at pH 8 100 mg Sb ₂ O ₃ in 1-L reconstituted water after 7 days (Measured)	Canada, 2010; OECD SIDS, 2008	This value, reported in secondary sources with limited details, is one order of magnitude (10 times) less than other reported values listed above. The difference between these values (approximately 3 and 30 mg) has no impact on the other endpoints in this assessment and may be a result of a typographical error in either study or differences in study methods, analysis, or reporting.
	<28.7 (Measured)	ERMA, 2011	Sufficient details were not available to assess the quality of this study.
	Dissolution in water decreases from pH 1 to pH 7. Above pH 7, the solubility increases rapidly to pH 8, at which point a new equilibrium is established. (Measured)	OECD SIDS, 2008	Within multiple studies the data demonstrate the pH dependency of antimony trioxide solubility.
Log K_{ow}			No data located; inorganic compounds are outside the estimation domain of EPI.
Flammability (Flash Point)	Not combustible (Measured)	ICSC, 2005	Adequate.
Explosivity	Not expected (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Pyrolysis	Not applicable (Estimated)	Professional judgment	Inorganic compounds do not undergo pyrolysis.
pH		Professional judgment	This substance is not expected to produce ions that would alter the pH of the solution in aqueous conditions.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pK _a				Not applicable; inorganic compounds are outside the estimation domain of SPARC (2009).
HUMAN HEALTH EFFECTS				
Toxicokinetics		Antimony trioxide is expected to have no absorption through skin and has poor absorption through the lungs and gastrointestinal (GI) tract according to experimental data. Following oral exposure, the majority of antimony trioxide is excreted in the feces. The compound accumulates in lungs with inhalation exposure due to slow absorption and clearance.		
Dermal Absorption <i>in vitro</i>		A percutaneous study in human skin showed 0.26% absorption	OECD SIDS, 2008	Reported in a secondary source, limited study details provided.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal, or Inhaled	Not absorbed through the skin; poor absorption through the lung and GI tract (Estimated by analogy)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
		Absorption in rats orally administered 2% antimony trioxide in the diet was distributed to the thyroid, GI contents, spleen, heart, bone, muscle, lungs, liver, and GI tissue. The highest concentrations (concentrations not specified) were found in the whole blood, thyroid, and bones. The majority (99%) is excreted in the feces and also in urine within 7 days post-exposure.	NTP, 2005; OECD SIDS, 2008	Reported in a secondary source, limited study details provided.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Six groups of Sprague-Dawley rats were administered antimony trioxide IP, IV, or by gavage (100 or 1,000 mg/kg-bw). Following oral administration, antimony trioxide had low absorption (0.3% of 100 mg/kg-bw; 0.05% of 1,000 mg/kg-bw), with a C _{max} at 24 hours and slower elimination from the blood. Antimony underwent significant distribution to the tissues with the majority being found in bone marrow and thyroid, followed by the ovaries, spleen, liver, lung, heart, femur, and skin. The majority of antimony trioxide was excreted in the feces and also in urine.	ECHA, 2011	Reported in a secondary source.
	Occupationally exposed smelter workers had increased (unspecified) levels of antimony in blood and urine following inhalation exposure	NTP, 2005	Reported in a secondary source, occupational reports, no exposure or duration details; detected concentrations not specified.
	Antimony has been detected in low (unspecified) amounts in human breast milk, placenta, amniotic fluid, umbilical cord blood, and fetal liver	OECD SIDS, 2008	Reported in a secondary source, limited study details provided; detected concentrations not specified.
	Dermal		No data located.
	Inhalation	EPA, 2002; NTP, 2005	Reported in a secondary source, limited study details provided; detected concentrations not specified.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Fischer 344 rats (65/sex/group) were exposed (whole-body) to antimony trioxide dust at target concentrations of 0, 0.05, 0.5, or 5.0 mg/m³ (duration-adjusted concentrations: 0, 0.01, 0.09, or 0.80 mg/m³) for 6 hours/day, 5 days/week, for 1 year. The mass median aerodynamic diameter (MMAD) was 3.7 microns, and sigma g was 1.7 for all concentrations. Some animals were held for an additional 1-year recovery period and interim sacrifices were made at the end of 6 and 12 months during exposure as well as the end of the 6- and 12-month post-exposure recovery time. Lung clearance times were 2.3, 3.6, and 9.5 months for the low, mid-, and high-concentration groups, exposed animals retained 10.6, 120, and 1,460 micrograms/g lung tissue in the three exposure groups, respectively, after 1 year of exposure.	EPA, 2002; Newton et al., 1994	The antimony trioxide atmosphere for treated rats was generated using fluidizing bed generators; resulting dust-laden streams were then delivered into inhalation chambers.
		Hamsters were exposed to pure antimony trioxide (volume median diameter of 7.0 microns) or dust containing 1.6% antimony (by weight) via intratracheal instillation and lung clearance was determined. The half-life of elimination from hamster lungs was 20–40 days.	EPA, 2002	Reported in a secondary source, limited study details provided.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Acute Mammalian Toxicity		LOW: Antimony trioxide is considered of low acute toxicity for oral, dermal, and inhalation exposure.		
Acute Lethality	Oral	No deaths were reported in rats administered antimony trioxide in food at $\leq 16,714$ mg/kg-day	ATSDR, 1992	Reported in a secondary source, limited study details provided.
		Rat oral LD ₅₀ >20,000 mg/kg	EU RAR, 2008	Reported in a secondary source
	Dermal	Rabbit dermal LD ₅₀ >8,300 mg/kg-bw	OECD SIDS, 2008	Reported in a secondary source, limited study details provided.
	Inhalation	Rat 4-hour LC ₅₀ >5,200 mg/m ³ dust (5.2 mg/L)	OECD SIDS, 2008	Reported in a secondary source, limited study details provided.
Carcinogenicity		MODERATE: There is limited evidence that inhalation of antimony trioxide is carcinogenic in rats. There was no carcinogenicity following inhalation to antimony trioxide dust in rats for 1 year. Other inhalation studies reported a potential for lung tumors; however, these studies may be considered unreliable due to study limitations. A 2 year cancer bioassay is in progress at National Toxicology Program (NTP).		
	OncoLogic Results			No data located. This inorganic compound is not amenable to available estimation methods.
	Carcinogenicity (Rat and Mouse)			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Chronic Toxicity/ Carcinogenicity	Wistar rats (45/sex/group) were exposed to 45 mg/m³ antimony trioxide dust (duration-adjusted concentration = 9.4 mg/m³; MMAD = 2.80) or 36–40 mg/m³ antimony ore (duration-adjusted = 7.9 mg/m³; MMAD = 4.78) up to 52 weeks at 7 hours/day, 5 days/week. Interim sacrifices were performed at 6, 9, and 12 months (5/sex/group) and the remaining animals were allowed to recover for 20 weeks. Slight decreases in body weight, and slightly raised white and yellow foci were observed on pleural surfaces in lung. After 6 months, all animals developed interstitial fibrosis, alveolar-wall cell hypertrophy, and hyperplasia, and cuboidal and columnar cell metaplasia of the lungs. The affected area increased in size after 12 months and the extent of fibrosis increased after 4–5 months recovery. An increased incidence (27%) of lung tumors (squamous-cell carcinomas, bronchoalveolar adenomas, bronchoalveolar carcinomas, and scirrhous carcinomas) was observed in females only, while no lung tumors were reported for controls.	Groth et al., 1986; EPA, 2002	Reported in a secondary source, limited study details provided. Only one concentration was tested. Study conducted prior to the implementation of guideline studies developed from standardized methodologies. The chemical substance used in testing also contained detectable levels of arsenic, a known human carcinogen.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Rats exposed via inhalation to 4.01 mg antimony/m ³ as antimony trioxide dust for 6 hours/day, 5 days/week for 1 year did not exhibit an increase in the incidence of lung tumors.	Newton et al. 1994; ATSDR, 1992; EPA, 2002	Reported in a secondary source, limited study details provided. Units measured as mg antimony/m ³ as antimony trioxide.
		Increased incidence of lung tumors was observed in female rats exposed to 4.2 or 36 mg antimony/m ³ as antimony trioxide dust 6 hours/day, 5 days/week, for 1 year.	Watt, 1980, 1983; ATSDR, 1992	Reported in a secondary source, limited study details provided. Units measured as mg antimony/m ³ as antimony trioxide. Only female rats were tested. Study conducted prior to the implementation of guideline studies developed from standardized methodologies.
Genotoxicity		MODERATE: Antimony trioxide does not appear to cause gene mutations in bacteria or mouse lymphoma cells <i>in vitro</i> . While antimony trioxide caused chromosomal aberrations in B6C3F1 mouse bone marrow, there were also negative results for chromosomal aberrations and micronuclei in <i>in vivo</i> studies of mice and rats. Positive results were found in an <i>in vivo</i> inhalation micronucleus assay in B6C3F1 mouse peripheral blood and bone marrow cells and for chromosomal aberrations in mouse bone marrow following oral exposure for 21 days but the study had limitations. <i>In vitro</i> induction of sister chromatid exchange (SCE) occurred in human lymphocytes and Chinese hamster V79 cells. Positive results were also observed in a cytogenetic assay in human lymphocytes.		
	Gene Mutation <i>in vitro</i>	Negative in two Ames tests using <i>Salmonella</i> strains TA1535, TA1537, TA100, TA98, and <i>E. coli</i> strains WP2PuvrA and WP2P.	EU RAR, 2008	Reported in a secondary source. Performed according to Organisation of Economic Cooperation and Development (OECD) Guideline 471 and good laboratory practice (GLP).
		Negative in the mouse lymphoma L5178Y mutation assay.	EU RAR, 2008	Reported in a secondary source. Performed according to OECD Guideline 476 and GLP.
	Gene Mutation <i>in vivo</i>			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Chromosomal Aberrations <i>in vitro</i>	Positive in a cytogenetic assay using human lymphocytes isolated from two different donors, with and without metabolic activation.	EU RAR, 2008	Reported in a secondary source. Performed according to OECD Guideline 473 and GLP.
		Positive for inducing SCE in human lymphocytes and V79 Chinese hamster cells.	EU RAR, 2008	Reported in a secondary source.
	Chromosomal Aberrations <i>in vivo</i>	Positive in micronucleus bone marrow and peripheral blood assay in B6C3F1 male and female mice, inhalation exposure.	NTP, 2011	Reported in a secondary source. Study results are limited because antimony trioxide appears to have effects on erythroid colony development.
		Negative for an increase in the incidence of micronuclei in CD-1 mice following single (5,000 mg/kg) or repeat (400, 667, or 1,000 mg/kg/day; males only) oral administration of antimony trioxide (bone marrow micronucleus assay).	EU RAR, 2008	Reported in a secondary source. Performed according to OECD Guideline 474 and GLP). No lethality reported.
		Negative in a chromosomal aberrations test in mouse bone marrow following single gavage administration of 400, 667 or 1,000 mg/kg bw to male and female Swiss albino mice (5/sex/group). Observations were made 6, 12, 18 and 24 hours post exposure.	EU RAR, 2008	Reported in a secondary source. Study results are limited because no positive control was used and is inadequate for determining hazard designation.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Positive in a chromosomal aberrations test in mouse bone marrow following repeated gavage administration of 400, 667 or 1,000 mg/kg bw to male Swiss albino mice (5/sex/group) daily for 21 days. Observations were made on days 7, 14, and 21. Frequencies of chromosomal aberrations were significantly increased in a dose-dependent manner, but did not show a duration-dependent association.	EU RAR, 2008	Reported in a secondary source. Study results are limited because only male mice were tested, exposure to the highest dose was lethal by day 20 of treatment, and no positive control was used. Lethality in this study was not seen in other studies at similar doses. Due to lethality, no chromosomal aberrations were evaluated in the high dose group on the day 21 observation. The EU RAR considers these results to be questionable due to the unexplained lethality in the high dose group, and inconsistencies in reporting.
		Negative for chromosome aberrations and micronuclei in the bone marrow of male and female Sprague-Dawley rats (6/group) administered 250, 500, or 1,000 mg/kg bw/day for 21 days. The mitotic index and percentage of polychromatic erythrocytes showed no evidence of bone marrow toxicity.	EU RAR, 2008	Reported in a secondary source. No lethality reported.
	DNA Damage and Repair	Positive in two <i>Bacillus subtilis</i> Rec assays using strains H17 (Rec ⁺) and M45 (Rec ⁻).	EU RAR, 2008	Reported in a secondary source.
		Negative in a rat liver unscheduled DNA synthesis study in male Alderly Park AlPk:ApfSD rats (5/dose) following a single oral dose of 3,200 or 5,000 mg/kg.	EU RAR, 2008	Performed according to OECD Guideline 486 and GLP.
	Other (Mitotic Gene Conversion)			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		MODERATE: Reproductive effects following inhalation exposure to antimony trioxide cannot be ruled out. A single reproductive study is available reporting a measured LOEC value of 0.21 mg/L antimony trioxide dust in rats for difficulty conceiving and reduced numbers of offspring however, this study has limitations. Oral repeated dose studies did not report changes in reproductive organs.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects	Rats exposed to 250 mg antimony trioxide dust/m ³ for 4 hours/day beginning 3–5 days before estrus, through mating and gestation, until 3-5 days before birth (total 63–78 days) had difficulty conceiving and delivered reduced numbers of offspring. LOAEC = 209 mg/m ³ (0.21 mg/L)	ATSDR, 1992; EPA, 2002	Reported in secondary sources; a NOAEC was not identified. There is uncertainty as to the lowest concentration at which effects might occur. It is possible effects may occur at lower concentrations. Only one concentration was tested. Study conducted prior to the implementation of guideline studies developed from standardized methodologies.
		Changes in menstrual cycles, spontaneous late abortions, and early interruption of pregnancies were reported for female workers exposed to antimony dusts at an antimony metallurgical plant	ATSDR, 1992; EPA, 2002	Occupational exposures involving mixed compounds, undefined control group; reported in a secondary source, limited study details provided.
		Rat and Mouse, oral (gavage), 4-week repeated dose study; No effects on testicular toxicity. NOAEL = 1,200 mg/kg-day (highest dose tested)	OECD SIDS, 2008	Reported in a secondary source; study was not designed as a reproductive study. It was not specified if other reproductive parameters were examined.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Wistar rats, male and female, dietary exposure 84–1,879 mg/kg-day for 90 days. No effects in testes $\leq$ 1,686 mg/kg-day; No effects in ovaries and uterus $\leq$ 1,879 mg/kg-day. NOAEL = 1,686 mg/kg-day (male) NOAEL = 1,879 mg/kg-day (female) LOAEL = not identified	OECD SIDS, 2008	Reported in a secondary source, study details and test conditions were not provided. Did not conduct a comprehensive evaluation of reproductive parameters, but did examine reproductive organs. Sources cited four significant figures in results.
Developmental Effects		LOW: Low potential for developmental effects based on expert judgment. Available data are insufficient to determine a hazard designation for this endpoint. The highest concentration tested was identified as a NOAEC (0.0063 mg/L), but a LOAEC was not identified. It is possible that effects could occur at concentrations that could be designated as Moderate or High potential for hazard if tested at higher concentrations.		
	Reproduction/ Developmental Toxicity Screen	Low potential for developmental effects (Estimated)	Expert judgment	Estimated based on expert judgment.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Prenatal Development	Rats (strain not specified; 26 females/group) received 0, 1.5, 3.0, or 6.0 mg/m³ antimony trioxide (actual concentrations delivered: 2.6, 4.4, or 6.3 mg/m³) by nose-only inhalation on gestation days (GD) 0 through 19 (6 hours/day). Particle size ranged from 1.59 - 1.82 microns. No mortalities and no treatment-related effects in the dams were reported for clinical signs, body weight change, or food consumption. No evidence of fetotoxicity was observed on GD 20 for implantation rate, fetal sex ratios, fetal body weights or crown-rump length, or fetal external, visceral, or skeletal examinations. Maternal gross examination revealed no treatment-related effects for clinical signs, food consumption or body weight changes; however, histopathologic examination found increased lung weight (24%, 31%, and 39% over controls at 2.6, 4.4, or 6.3 mg/m³, respectively) at every dose level, with diffuse accumulation of pigmented alveolar macrophages, likely due to phagocytosis and accumulation of particulate matter of the test substance. NOAEC developmental = 6.3 mg/m³ (0.0063 mg/L, highest dose tested) LOAEC developmental = not established NOAEC maternal = not established LOAEC maternal = 2.6 mg/m³ (0.0026 mg/L)	International Antimony Oxide Industry Association, 2004	Reported in secondary source; a LOAEL for developmental toxicity was not identified in the study. The highest dose tested did not result in developmental effects.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Increased incidence of spontaneous abortions in female workers at an antimony metallurgy plant.	ATSDR, 1992	Reported in a secondary source, limited study details provided. Occupational exposures involving mixed compounds, undefined control group.
	Postnatal Development			No data located.
Neurotoxicity		LOW: Potential for neurotoxicity based on professional judgment. The experimental LOAEL values (6,544 mg/kg-day) for dogs and rabbits fall into the LOW hazard criteria range.		
	Neurotoxicity Screening Battery (Adult)			No data located.
	Developmental Neurotoxicity			No data located.
	Other Neurotoxicity	Dogs developed muscle weakness and difficulty moving the hind limbs when administered antimony trioxide by gavage for 32 days. LOAEL = 6,544 mg/kg-day (only dose tested)	ATSDR, 1992	Reported in a secondary source, no study details or test conditions provided. A NOEL was not identified. There is uncertainty as to the lowest dose at which effects might occur. It is possible effects may occur at lower doses that would warrant a moderate or high hazard designation.
		Abnormal gait was observed in rabbits following a single dermal application LOAEL= 6,685 mg/kg-day (only dose tested).	ATSDR, 1992	Reported in a secondary source, limited study details provided. This was a lethal dose in the range finding study. A NOEL was not identified. There is uncertainty as to the lowest dose at which effects might occur. It is possible effects may occur at lower doses that would warrant a moderate or high hazard designation.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects	HIGH: Based on inhalation repeated dose LOAEC values ranging from 0.00092 to 0.045 mg/L dust in experimental animals. Toxicity following inhalation of antimony trioxide dust is due to impaired lung clearance and particle overload followed by inflammatory responses and fibrosis. LOAEL values indicate a low hazard for repeated dose effects following oral administration and toxicokinetic studies indicate that antimony trioxide is poorly absorbed when administered orally. A 2-year inhalation cancer bioassay in rats and mice is in progress at NTP.		
	Several occupational studies examined mine and smelter workers exposed to airborne dust concentrations of up to 138 mg/m ³ antimony trioxide (0.138 mg/L), and particle size averaging <5 mm, concentrated in the mid lung region. A common finding in the subjects examined was antimony pneumoconiosis characterized by diffuse, densely distributed punctuate opacities, having a round, polygonal or irregular shape, and averaging <1 mm diameter.	EPA, 2002	Reported in a secondary source; occupational exposures to airborne mixtures of antimony trioxide and/or pentoxide.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	24 guinea pigs were exposed to 45.4 mg/m³ antimony trioxide dust (approximately 38.1 mg antimony/m³) 2 hours/day, 7 days/week for 2 weeks followed by 3 hours/day for 8–265 days. Particle size was assumed to be <1 micron. Necropsy revealed increased lung weight, interstitial pneumonitis, and subpleural petechial hemorrhages in animals exposed for ≥30 days. Increased liver weight, fatty degeneration, and cloudy swelling of the liver were noted in animals exposed for ≥48 days, and decreased white blood counts and splenic hypertrophy and hyperplasia were seen in about 50% of the exposed animals. LOAEC = 45.4 mg/m³ (0.045 mg/L)	EPA, 2002	Reported in a secondary source, study details and test conditions were not provided. Only one concentration tested. Study conducted prior to the implementation of guideline studies developed from standardized methodologies.
	Inhalation exposure of rats, 6 hours/day, 5 days/week ≥13 weeks resulted in proliferation of alveolar macrophages. LOAEC = 0.92 mg/m³ (0.00092 mg/L)	ATSDR, 1992	Reported in a secondary source, study details and test conditions were not provided. Study conducted prior to the implementation of guideline studies developed from standardized methodologies.
	Dogs developed severe diarrhea and muscle weakness when administered antimony trioxide by gavage for 32 days. LOAEL = 6,544 mg/kg/day	ATSDR, 1992	Reported in a secondary source, study details and test conditions were not provided.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fischer 344 rats (50/sex/group) were exposed to target concentrations of 0, 0.2, 1.0, 5.0, or 25.0 mg/m³ (actual concentrations were 0, 0.25, 1.08, 4.92, or 23.46 mg/m³) for 6 hours/day, 5 days/week, 13 weeks (duration-adjusted concentrations = 0, 0.05, 0.19, 0.88, or 4.20 mg/ m³, respectively). Interim sacrifices (5/sex/group) were conducted at weeks 1, 2, 4, 8, and 13, and some animals were held an additional 27 weeks for recovery. Complete gross and histopathological examinations were conducted on all animals, while hematology and clinical chemistry analysis were performed for 5/sex/group at exposure and recovery weeks 1,2,4,8, and 13. Body weight in males and females was reduced at the two highest concentrations, and mean and absolute lung weights were increased in both sexes at the two highest concentrations during exposure and early part of recovery. Gross necropsy revealed discolored lungs and microscopic examination found particle-laden and degenerating macrophages, cellular debris in the lumen of the alveoli, pneumatocyte hyperplasia, and alveolar wall thickening, which were still present at week 27 of recovery. NOAEL = 1.08 mg/m³ (0.0011 mg/L) LOAEL = 4.92 mg/m³ (0.0049 mg/L)	Newton et al., 1994; EPA, 2002	Reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fischer 344 rats (65/sex/group) were exposed (whole-body) to antimony trioxide at target concentrations of 0, 0.05, 0.5, or 5.0 mg/m³ (duration-adjusted concentrations: 0, 0.01, 0.09, or 0.80 mg/ m³) for 6 hours/day, 5 days/week for 1 year. Some animals were held for an additional 1-year recovery period and interim sacrifices were made at the end of 6 and 12 months during exposure as well as the end of the 6- and 12-month post-exposure recovery time. Gross and histopathological examinations were conducted on all animals and hematology analyses were performed on subgroups at 12, 18, and 24 months. Ophthalmoscopic evaluation found an 11, 2, 28 and 32% increased incidence of cataracts from lowest to highest test concentration, respectively. Interstitial inflammation and granulomatous inflammation were observed at all concentrations. Statistical analysis indicated a significant increase in incidence and severity of these effects at the high exposure in both sexes. Pulmonary clearance was decreased by 80% in the high concentration group and the clearance halftime was increased from 2 months to 10 months. LOAEC = 0.05 mg/m³ (0.0005 mg/L)	Newton et al., 1994; EPA, 2002	Reported in a secondary source, not a guideline study.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Wistar rats (50 females/group) and Sinclair S-1 miniature pigs (3 females/group) to 0, 1.9, or 5.0 mg/m³ (duration-adjusted concentrations = 0, 0.3, and 0.9 mg/m³, respectively) antimony trioxide for 6 hours/day, 5 days/week for 1 year. Particle size was 0.44 and 0.40 microns for the low and high concentrations, respectively. Survival, hematology and clinical chemistry were not affected by exposure for either species. Lung weights were increased and pulmonary focal fibrosis, adenomatous hyperplasia, multinucleated giant cells, cholesterol clefts, pneumonocyte hyperplasia, and pigmented macrophages were observed. Necropsy revealed pulmonary discoloration and increased alveolar-intralveolar macrophages in both exposure groups, while focal subacute-chronic interstitial inflammation and granulomatous inflammation observed in the high exposure group. LOAEC = 1.9 mg/m³ (0.0019 mg/L, lowest concentration tested)	EPA, 2002	Reported in a secondary source. Study conducted prior to the implementation of guideline studies developed from standardized methodologies.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Wistar rats, male and female, dietary exposure of 0, 1,000, 5,000, or 20,000 ppm (male: 0, 84, 421, 1,686 mg/kg-day; female: 0, 97, 494, 1,879 mg/kg-day) for 90 days. In high-dose males: increased triglycerides, red blood cells, and urine volume; decreased alkaline phosphatase activity. In high-dose females: increased red blood cells, urine volume, serum cholesterol, and aspartate and alanine aminotransferase; decreased alkaline phosphatase activity (mid-dose too) and urine specific gravity. NOAEL = 5,000 ppm (494 and 421 mg/kg-day in females and males, respectively) LOAEL = 20,000 ppm (1,879 and 1,686 mg/kg-day in females and males, respectively)	NTP, 2005	Reported in a secondary source.
	Male Wistar rats, dietary exposure, 500 or 1,000 mg antimony trioxide/kg-day, for 24 weeks. Decreased red blood cell count; increased serum glutamic oxaloacetic transaminase. LOAEL = 500 mg/kg-day	NTP, 2005	Reported in a secondary source, study details and test conditions were not provided.
	Rats (strain and sex not given), dietary exposure, 670 mg antimony trioxide/kg-day, for 12 weeks. Decreased weight gain, spleen weight, and heart weight; increased lung weight. LOAEL = 670 mg/kg-day (only dose tested)	NTP, 2005	Reported in a secondary source, study details and test conditions were not provided.

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Antimony Trioxide CASRN 1309-64-4				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Rats (strain and sex not given), dietary exposure, 420–490 mg antimony trioxide/kg-day for 24 weeks. Decreased weight gain, decreased red blood cells, and cloudy swelling in hepatic cords. LOAEL = 418 mg/kg-day	ATSDR, 1992; NTP, 2005	Reported in a secondary source, study details and test conditions were not provided.
Skin Sensitization		LOW: Antimony trioxide was not sensitizing in guinea pigs.		
	Skin Sensitization	Not sensitizing to guinea pigs.	OECD SIDS, 2008	Reported in a secondary source, limited study details provided.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Antimony trioxide is mildly irritating to rabbit eyes.		
	Eye Irritation			
		Instillation of 34.5–83.6 mg antimony (as antimony trioxide) into the eyes of rabbits did not produce irritation.	ATSDR, 1992	Reported in a secondary source, limited study details provided.
		Two studies showed reversible mild eye irritation in rabbits.	OECD SIDS, 2008	Reported in a secondary source, limited study details provided.
Dermal Irritation		MODERATE: Antimony trioxide is reported to produce skin irritation in workers.		
	Dermal Irritation	Human case study reports have indicated that antimony trioxide may cause dermatitis on damp skin; irritation associated with sweat ducts.	OECD SIDS, 2008	Reported in a secondary source, human case study reports.
Endocrine Activity		No data located.		
				No data located.

Antimony Trioxide CASRN 1309-64-4				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Immunotoxicity		Inhalation exposure to antimony trioxide caused decreased white blood counts and splenic hypertrophy and hyperplasia in guinea pigs.		
	Immune System Effects	24 guinea pigs were exposed to 45.4 mg/m³ antimony trioxide dust (approximately 38.1 mg antimony/m³) 2 hours/day, 7 days/week for 2 weeks followed by 3 hours/day for 8–265 days. Particle size was assumed to be <1 micron. Decreased white blood counts and splenic hypertrophy and hyperplasia were seen in about 50% of the exposed animals. LOAEC = 45.4 mg/m³ (0.045 mg/L)	EPA, 2002	Reported in a secondary source, no study details and test conditions were provided. Only one concentration tested.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		HIGH: Based on the acute toxicity value of 1.77 mg antimony (Sb)/L in <i>Chlorohydra viridissima</i>. Some experimental acute toxicity values for fish and daphnia were in the Moderate hazard range, while other experimental aquatic toxicity values for fish and daphnia exceed the water solubility of the compound. Studies for algae were inadequate due to study limitations and uncertainties.		
Fish LC₅₀		<i>Lepomis macrochirus</i> 96-hour LC ₅₀ >530 mg/L (Experimental)	ECOTOX	Inadequate; data exceeds measured water solubility of compound; limited data make it difficult to determine whether the data refer to antimony ion or antimony trioxide.
		<i>Danio rerio</i> 96-hour LC ₅₀ >1,000 mg/L (Experimental)	IUCLID, 2000	Inadequate; data exceeds measured water solubility of compound; limited data make it difficult to determine whether the data refer to antimony ion or antimony trioxide.

Antimony Trioxide CASRN 1309-64-4

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	<i>Pimephales promelas</i> 96-hour LC ₅₀ >80 mg/L (Experimental)	ECOTOX	Inadequate; data exceeds measured water solubility of compound; limited data make it difficult to determine whether the data refer to antimony ion or antimony trioxide.
	<i>Pimephales promelas</i> 96-hour LC ₅₀ = 14.4 mg Sb/L (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as SbCl ₃ .
	<i>Pagrus major</i> (marine) 96-hour LC ₅₀ = 6.9 mg Sb/L (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as SbCl ₃ ; uncertainties exist regarding test concentrations and speciation so this study was not considered when designating hazard for this endpoint.
Daphnid LC₅₀	<i>Daphnia magna</i> 48-hour EC ₅₀ = 423 mg/L (Experimental)	ECOTOX	Inadequate; data exceeds measured water solubility of compound; limited data make it difficult to determine whether the data refer to antimony ion or antimony trioxide.
	<i>Daphnia magna</i> 48-hour EC ₅₀ >1,000 mg/L (Experimental)	IUCLID, 2000	Inadequate; data exceeds measured water solubility of compound; limited data make it difficult to determine whether the data refer to antimony ion or antimony trioxide.
	<i>Daphnia magna</i> 48-hour LC ₅₀ = 12.1 mg Sb/L (Experimental)	EU RAR, 2008	Reported in a secondary source.
Other Aquatic Invertebrates	<i>Chlorohydra viridissima</i> (hydra), 96-hour LC ₅₀ = 1.77 – 1.95 mg Sb/L; measured filtered (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as SbCl ₃ ; reliable study conducted in a sensitive species.

Antimony Trioxide CASRN 1309-64-4

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Green Algae EC₅₀	<i>Pseudokirchneriella subcapitata</i> 72-hour EC ₅₀ = 0.73 mg /L (Estimated; based on chlorophyll A concentration)	ECOTOX	Inadequate; reported in a secondary source; not a traditional endpoint for determining hazard potential; <i>Pseudokirchneriella subcapitata</i> is more recently known as <i>Raphidocelis subcapitata</i> .
	<i>Raphidocelis subcapitata</i> 72-hour EC ₅₀ >36.6 mg Sb/L (growth rate) NOEC = 2.11 mg Sb/L (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as SbCl ₃ .
	<i>Raphidocelis subcapitata</i> 72-hour EC ₅₀ >2.4 mg Sb/L (growth rate) There was a 3% inhibition of growth rate at the limit concentration (2.4 mg/L) NOEC = 0.396 mg Sb/L LOEC = 1.32 mg Sb/L (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as Sb ₂ O ₃ ; uncertainties exist regarding the concentration response since the limit concentration resulted in only a 3% inhibition of growth rate which is considered the most sensitive endpoint; it is unclear where a significant inhibition of growth would occur.
	<i>Lemma minor</i> 96-hour EC ₅₀ >25.5 mg Sb/L; NOEC = 12.5 mg Sb/L LOEC = 25.5 mg Sb/L (reduction in frond production) (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as SbCl ₃ .
Chronic Aquatic Toxicity	MODERATE: Based on experimental LOECs ranging from 2.31 to 4.50 mg Sb/L in fish and daphnia.		
Fish ChV	<i>Pimephales promelas</i> 28-day NOEC = 2.31 mg Sb/L; LOEC 4.50 mg Sb/L (growth – weight) (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as SbCl ₃ .

Antimony Trioxide CASRN 1309-64-4

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	<i>Pimephales promelas</i> 28-day NOEC = 1.13 mg Sb/L (growth – length); LOEC = 2.31 mg Sb/L (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as SbCl ₃ .
	<i>Pimephales promelas</i> 28-day NOEC >0.0075 mg Sb/L (growth) (Experimental)	EU RAR, 2008	Reported in a secondary source. There were no effects reported at the highest dose tested. Test substance identified as Sb ₂ O ₃ .
Daphnid ChV	<i>Daphnia magna</i> 21-day NOEC = 1.74 mg Sb/L; LOEC = 3.13 mg Sb/L (Experimental)	EU RAR, 2008	Reported in a secondary source. Test substance identified as SbCl ₃ .
	<i>Daphnia</i> ChV = 3.8 mg/L (Estimated)	EPI; Professional judgment	Based on SARs (not computerized) developed for confidential antimony salts.
Green Algae ChV			No data located.
Chronic Toxicity to Soil Invertebrates	<i>Folsomia candida</i> (springtails) in Sb₂O₃-amended soil at measured concentrations of 90, 322, 999, 2,930, and 10,119 mg Sb/kg soil dry weight (dw). Controls of uncontaminated field soil and an untreated artificial soil were used and a positive control using the herbicide Betosip was used. 28-day LC₅₀ and EC₅₀ (reproduction) >10,119 mg Sb/kg dw NOEC (reproduction) = 999 mg Sb/kg dw LOEC (reproduction) = 2,930 mg Sb/kg dw (Experimental)	Moser, 2007	Study conducted according to OECD 207.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The limited mobility observed under experimental conditions and the low vapor pressure indicates that antimony trioxide is anticipated to partition predominantly to soil and sediment. It will not volatilize from water. Soil mobility and sediment adsorption tests indicate that antimony trioxide will be immobile in soil, and therefore will not be expected to migrate into groundwater.		
	Henry's Law Constant (atm-m³/mole)	<10 ⁻⁸ (Estimated)	Professional judgment	Cutoff value for non-volatile compounds. This inorganic compound is not amenable to available estimation methods.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	No significant evidence of mobility in sand, clay, or sandy and silt loams when tested at 100 µL concentration after 24 hours (Non-TSCA Protocol/Guideline) (Measured)	EPA, 2006; EPA, 2004	Although not a guideline study, the data suggest that antimony trioxide will have a K _{oc} >30,000, the cutoff value for non-mobile substances.
	Level III Fugacity Model			Not all input parameters for this model were available to run the estimation software (EPI).
Persistence		HIGH: Antimony trioxide is an inorganic substance containing metallic atoms that are likely to be found in the environment for more than 180 days after release, resulting in a very high persistence/recalcitrant hazard designation. Based on water solubility studies under a range of pH values, antimony trioxide is expected to slowly dissolve resulting in the release of antimony ions and, depending on pH, be oxidized or reduced to other oxidation states. Additionally, results from a pure culture study using autotrophic bacterium indicate that antimony may be oxidized by bacteria. Antimony trioxide is not anticipated to undergo hydrolysis under environmental conditions. Antimony trioxide does not contain functional groups expected to absorb light at environmentally significant wavelengths, and therefore is not expected to photolyze. No degradation processes for antimony trioxide under typical environmental conditions were identified.		
Water	Aerobic Biodegradation			No data located.
	Volatilization Half-life for Model River			No data located.
	Volatilization Half-life for Model Lake			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Soil	Aerobic Biodegradation	Autotrophic bacteria, <i>Stibiobacter senarmonitii</i> , were grown in a mineral medium containing antimony trioxide during a pure culture study. Antimony trioxide was oxidized at rates of 45.5–51.6 and 13.5–19.3 mg/month for senarmonite and valentinite, respectively; little oxidation occurred in the sterile medium. (Measured)	EPA, 1985	Nonguideline study that demonstrated that the half-life of antimony trioxide is anticipated to be >180 days.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation	10 and 100 ppm antimony trioxide with added nutrients were incubated with natural bottom sediment from Puget Sound under aerobic or anaerobic conditions for up to 120 days. Three organoantimony biotransformation products were found in solution after 60 days. Two of these were identified as methylstibonic acid and dimethylstibonic acid. No determination of rate or conditions affecting the transformation was made. However, it was estimated that much less than 0.1% of the antimony present was transformed. (Measured)	ATSDR, 1992	Nonguideline study reported in a secondary source that demonstrated limited biodegradation.
Air	Atmospheric Half-life			No data located.

Antimony Trioxide CASRN 1309-64-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reactivity	Photolysis	Not a significant fate process (Estimated)	Boethling and Mackay, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	Reacts with acids producing Sb ³⁺ compounds and bases producing [Sb(OH) ₄] ⁻ (Measured)	UBA, 2001	Although hydrolysis may occur upon contact with strong acids or bases, these data do not address the potential for hydrolysis under environmental conditions.
Environmental Half-Life		>180 days (Estimated)	Professional judgment	Antimony trioxide is an inorganic compound. Antimony ions, oxides, or hydroxides are expected to be found in the environment >180 days after release.
Bioaccumulation		LOW: Antimony trioxide is an inorganic compound and is not expected to bioaccumulate.		
	Fish BCF	<100 (Estimated)	Professional judgment	Antimony trioxide is an inorganic compound and is not anticipated to bioaccumulate or bioconcentrate.
		No reliable bioaccumulation or bioconcentration studies located.	OECD SIDS, 2008	
	BAF	<100 (Estimated)	Professional judgment	This inorganic compound is not amenable to available quantitative structure activity relationship models.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		Antimony trioxide has been detected in dust samples collected downwind from a copper smelting plant in Washington state (Crecelius et al., 1975, as described in EPA, 1985). Antimony is thought to oxidize to antimony trioxide in combustion and incineration processes (EU RAR, 2008). Antimony trioxide is found naturally occurring in ores such as senarmonite, valentinite and exitelite (Canada, 2010).		
Ecological Biomonitoring		No data located.		

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Human Biomonitoring	Women working in an antimony metallurgical plant, exposed to unspecified amounts of antimony trioxide, metallic antimony, and antimony pentasulfides were compared with a similar group of women not exposed to antimony. The plant workers had ten times the antimony concentration in their blood compared to controls; additional sampling was performed on urine, breast milk, placental tissue, amniotic fluid and umbilical cord blood samples (EPA, 1985). This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011). Additionally, it was reported that antimony has been found in fetal liver as well as in human breast milk, placenta, amniotic fluid and umbilical cord blood (EU RAR, 2008).		

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Bis(hexachlorocyclopentadieno) Cyclooctane

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

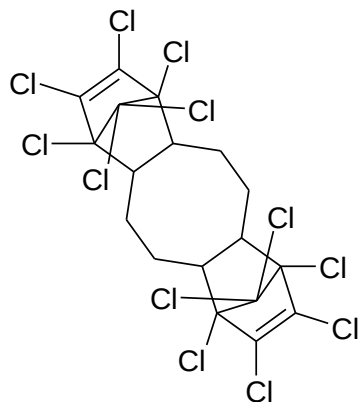
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

[§] Based on analogy to experimental data for a structurally similar compound.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Bis(hexachlorocyclopentadieno) Cyclooctane	13560-89-9	L	M [§]	M [§]	VL	VL	L	M	L		VL	L	L	L	VH	H

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Bis(hexachlorocyclopentadieno) Cyclooctane



CASRN: 13560-89-9

MW: 653.73

MF: C₁₈H₁₂Cl₁₂

Physical Forms:

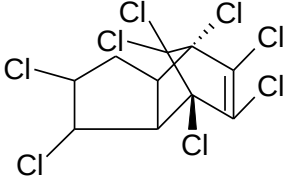
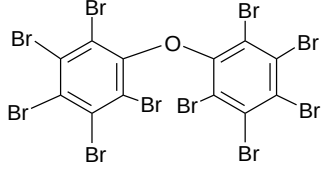
Neat: Solid

Use: Flame retardant

SMILES: C(=C(C(C1(Cl)Cl)Cl)(C(C2CCC(C(C(=C(C34Cl)Cl)Cl)(C3(Cl)Cl)Cl)C4C5)C5)Cl)Cl)(C12Cl)Cl

Synonyms: 1,4:7,10-Dimethanodibenzo[a,e]cyclooctene, 1,2,3,4,7,8,9,10,13,13,14,14-dodecachloro-1,4,4a,5,6,6a,7,10,10a,11,12,12a-dodecahydro-; 1,2,3,4,7,8,9,-10,13,13,14,14-Dodecachloro-1,4,4a,5,6,6a,7,10,10a,11,12,12a-dodechydro-1,4:7,10-dimethanodibenzo[a,e]cyclooctene; 1,4:7,10-Dimethanodibenzo(a,e)cyclooctene,1,2,3,4,7,8,9,10,13,13,14,14-dodecachloro-1,4,4a,5,6,6a,7,10,10a,11,12,12a-dodecahydro-; 1,6,7,8,9,14,15,16,17,17,18,18-Dodecachloropentacyclo(12.2.1.16,9.02,13.05,10)octadeca-7,15-diene; Bis(hexachlorocyclopentadieno)cyclooctane; Dechloran A; Dechlorane 605; Dechlorane Plus; Dechlorane Plus 1000; Dechlorane Plus 25; Dechlorane Plus 2520; Dechlorane Plus 35; Dechlorane Plus 515; Dodecachlorododecahydrodimethanodibenzocyclooctane; Dodecachlorododecahydrodimethanodibenzocyclooctene; Dodecachloropenta-cyclooctadeca-7,15 diene

Chemical Considerations: This is a discrete organic chemical with a MW below 1,000. EPI v 4.0 was used to estimate physical/chemical and environmental fate values due to an absence of experimental data. Measured values from experimental studies were incorporated into the estimations.

Polymeric: No Oligomers: Not applicable	
Metabolites, Degradates and Transformation Products: None	
Analogs: Chlordane (57-74-9), decabromodiphenyl ether (decaBDE) (1163-19-5, organochlorine pesticides, and confidential structures Endpoint(s) using analog values: Carcinogenicity, genotoxicity, repeated dose	Analog Structures:  Chlordane (57-74-9)  DecaBDE (1163-19-5)
Structural Alerts: Aliphatic halogenated hydrocarbons, cyclic halogenated hydrocarbons for neurotoxicity, and chlorinated hydrocarbons for reproductive toxicity (EPA, 2011).	
Risk Phrases: Not classified by Annex I Directive 67/548/ European Economic Community & IUCLID (Pakalin et al., 2007).	
Hazard and Risk Assessments: Risk assessment completed for bis(hexachlorocyclopentadieno) cyclooctane by the European Chemicals Bureau in 2007 (Pakalin et al., 2007).	

Bis(hexachlorocyclopentadieno) Cyclooctane CASRN 13560-89-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	Decomposes at 350°C (Measured)	Occidental Chemical Company, 2009	Material decomposes before melting.
Boiling Point (°C)	Decomposes at 350°C (Measured)	Occidental Chemical Company, 2009	Material decomposes before boiling.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	EPI; EPA, 1999	Cutoff value for non-volatile compounds according to HPV assessment guidance.
	0.006 at 200°C (Measured)	Occidental Chemical Company, 2009	Value reported at an elevated temperature.
Water Solubility (mg/L)	4.4x10 ⁻⁵ (Measured)	Occidental Chemical Company, 2009	Adequate, nonguideline study.
	2.49x10 ⁻⁴ (Measured)	Occidental Chemical Company, 2009	
	2.07x10 ⁻⁴ to 5.72x10 ⁻⁴ (Measured)	Chou et al., 1979	
Log K_{ow}	11 (Estimated)	EPI; EPA, 1999	Estimated value is greater than the cutoff value, >10, according to methodology based on HPV assessment guidance.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize in environmental conditions.
pK_a	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize in environmental conditions.

Bis(hexachlorocyclopentadieno) Cyclooctane CASRN 13560-89-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		As a neat material, bis(hexachlorocyclopentadieno) cyclooctane is estimated to not be absorbed through the skin and it is also estimated to have poor skin absorption when in solution. This compound is expected to be poorly absorbed via the lungs and gastrointestinal tract. Bis(hexachlorocyclopentadieno) cyclooctane is not easily absorbed in the gastrointestinal tract with 93-98% of an administered dose excreted through the feces unchanged. Plasma levels peaked at 10 hours after administration; the highest levels of bis(hexachlorocyclopentadieno) cyclooctane were found in the liver, where metabolism is thought to take place, and in the ovaries. Bis(hexachlorocyclopentadieno) cyclooctane is excreted slowly if it is absorbed.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal, or Inhaled	Not absorbed through the skin as the neat material; poor skin absorption if in solution; poor absorption from the lung and gastrointestinal tract (Estimated)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
		In a toxicokinetic study, most excretion occurred through the feces unchanged (93-98%), less than 0.1% was excreted in urine and 0.004% excreted in expired air; plasma levels peaked at 10 hours, and tissue levels did not increase proportionally with dose; after 4 days, 26% of radiolabeled chemical was remaining in carcass; the highest levels were found in the ovaries and liver.	IUCLID, 2003	Guideline study.
	Oral	In a toxicokinetic study in rats, very little of the chemical is absorbed in the gastrointestinal tract; 95% of administered radioactive dose was excreted in the feces; the small amount of chemical that did absorb was then excreted slowly; after absorption, the highest amount was found in the liver where metabolism takes place	Chou et al., 1979	Unpublished study, but sufficient study details reported.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Acute Mammalian Toxicity		LOW: Based on the acute oral and dermal toxicity values >3,160 mg/kg in rats and >8,000 mg/kg in rabbits, respectively. Although the acute inhalation study in rats produced no deaths, the LC ₅₀ value of >2.25 mg dust/L air (highest concentration tested) was not included in the hazard designation because there is uncertainty regarding the potential for adverse effects between 2.25 and 5 mg/L.		
Acute Lethality	Oral	Rat (Sherman-Wistar) oral LD ₅₀ >25,000 mg/kg; no mortalities at highest dose tested (25,000 mg/kg)	Occidental Chemical Company, 1992	Not specified as a guideline study, but follows general Organisation of Economic Cooperation and Development (OECD) guidelines.
		Rat (Sprague-Dawley) oral LD ₅₀ >3,160 mg/kg; no mortalities at the highest dose tested (3,160 mg/kg)	IUCLID, 2003	Not specified as a guideline study and reported in a secondary source, but follows general OECD guidelines.
	Dermal	Rabbit dermal LD ₅₀ >8,000 mg/kg; no mortalities at highest dose tested (8,000 mg/kg)	Occidental Chemical Company, 1992	Not specified as a guideline study, but follows general OECD guidelines.
	Inhalation	Rat inhalation 1-hour LC ₅₀ >300 mg dust/L air; no mortalities at highest dose tested (300 mg dust /L air)	IUCLID, 2003	Limited study details reported in a secondary source; not the preferred 4-hour exposure.
		Rat inhalation 4-hour LC ₅₀ >2.25 mg dust/L air (2,250 mg/m ³); no mortalities at highest dose tested (2.25 mg dust/L air)	Occidental Chemical Company, 1992	Not specified as a guideline study, but follows general OECD guidelines.
Carcinogenicity		MODERATE: There is potential for carcinogenicity based on analogy to chlordane and decaBDE, the latter for expression of adverse effects in longer term studies. No carcinogenicity data regarding exposure to Bis(hexachlorocyclopentadieno) cyclooctane located.		
	OncoLogic Results			Not amenable to available estimation method.
	Carcinogenicity (Rat and Mouse)	There is potential for oncogenicity (Estimated by analogy)	Professional judgment	Estimated by analogy to chlordane.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Potential for carcinogenicity; increased incidence of neoplastic nodules of the liver in rats; equivocal evidence of increased incidences of hepatocellular adenomas or carcinomas and thyroid gland follicular cell adenomas or carcinomas in male mice. (Estimated by analogy)	Professional judgment	Estimated based on the high potential for bioaccumulation and by analogy to observations on decaBDE where adverse effects were not present in 90-day studies but were expressed following chronic exposure in a National Toxicology Program (NTP) study.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		MODERATE: There is estimated to be an uncertain potential for mutagenicity based on analogy to chlordane. Bis(hexachlorocyclopentadieno) cyclooctane did not cause mutations in bacterial cells or mammalian cells <i>in vitro</i>. A moderate hazard designation is assigned because of the uncertain potential for genotoxicity based on chlordane and because there were no data located regarding the potential for bis(hexachlorocyclopentadieno) cyclooctane to cause chromosomal aberrations.		
	Gene Mutation <i>in vitro</i>	Uncertain potential for mutagenicity (Estimated by analogy)	Professional judgment	Estimated by analogy to chlordane.
		Negative, Ames assay in <i>Salmonella typhimurium</i> strains TA98, TA100, TA1535, TA1537, TA1538 with and without metabolic activation.	IUCLID, 2003	Not specified as a guideline study and reported in a secondary source, but follows general OECD guidelines.
		Negative, Mouse lymphoma assay in L5178Y TK +/- cells with and without metabolic activation.	IUCLID, 2003	Not specified as a guideline study and reported in a secondary source, but follows general OECD guidelines.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>			No data located.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		VERY LOW: Bis(hexachlorocyclopentadieno) cyclooctane did not cause reproductive effects at oral doses as high as 5,000 mg/kg-day in a combined repeated dose/reproduction/developmental toxicity study in rats.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	No adverse effects were observed in an oral (gavage) developmental and reproductive toxicity study in male and female rats (exposure to males: 21 days pre mating, 14 day mating period, and 28 days after completion of mating period; exposure to females: 21 days pre mating, 14 days mating, and up to 25 days after mating [gestation days (GD) 0 – lactation day (LD) 3]); no effects on reproductive or fertility indices through LD 4, and no effects on implantation or fetal indices through GD 20. NOEL = 5,000 mg/kg-day (highest dose tested)	Brock et al., 2010	Guideline study (OECD 422).
	Reproduction and Fertility Effects			No data located.
Developmental Effects		VERY LOW: Bis(hexachlorocyclopentadieno) cyclooctane did not cause developmental effects at oral doses as high as 5,000 mg/kg-day in a combined repeated dose/reproduction/developmental toxicity study in rats.		
	Reproduction/ Developmental Toxicity Screen			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	No adverse effects were observed in an oral (gavage) developmental and reproductive toxicity study in male and female rats (exposure to males: 21 days pre mating, 14 day mating period, and 28 days after completion of mating period; exposure to females: 21 days pre mating, 14 days mating, and up to 25 days after mating [GD 0–LD 3]); no effects on fetal development through LD 4, and no effects on external and visceral examinations through GD 20. NOEL = 5,000 mg/kg-day (highest dose tested)	Brock et al., 2010	Guideline study (OECD 422).
	Prenatal Development			No data located.
	Postnatal Development			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Neurotoxicity		LOW: Bis(hexachlorocyclopentadieno) cyclooctane did not cause neurotoxic effects at oral doses as high as 5,000 mg/kg-day in a combined repeated dose/reproduction/developmental toxicity study in rats.		
	Neurotoxicity Screening Battery (Adult)	No adverse effects were observed in a 28-day oral (gavage) study in male and female rats; no effects observed in functional observational battery evaluations (activity/arousal, autonomic, neuromuscular, physiological, and sensimotor); a significant lower frequency of urination was observed in females exposed to 750 and 5,000 mg/kg-day, but was not considered biologically significant; a significant increase in rearing counts for males exposed to 1,500 mg/kg-day during 20-30-min. trials, but was considered not to be treatment related. NOEL = 5,000 mg/kg-day (highest dose tested)	Brock et al., 2010	Guideline study (OECD 422).

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects	MODERATE: Bis(hexachlorocyclopentadieno) cyclooctane caused adverse liver and lung effects in rats following inhalation exposure to 0.64 mg dust/L (lowest concentration tested). No NOAEL was identified in this study so it is possible that effects could occur at lower concentrations. Bis(hexachlorocyclopentadieno) cyclooctane did not cause systemic effects at oral doses up to 5,000 mg/kg-day in a 28-day combined repeated dose/reproduction/developmental toxicity study in rats, in a 90-day dietary exposure study in rats at concentrations up to 100,000 ppm in the diet, or in a 28-day dermal exposure study in rabbits at doses up to 2,000 mg/kg-day. There is potential for chloracne estimated by analogy to organochlorine pesticides and potential for systemic effects estimated based on the high potential for bioaccumulation and potential for expression of adverse effects in longer term studies by analogy to decaBDE.		
	There is a potential for chloracne. (Estimated by analogy)	Professional judgment	Estimated by analogy to organochlorine pesticides.
	No adverse effects were observed in a 28-day oral (gavage) study in male and female rats; no effects on in-life parameters (clinical signs, food consumption, body weight), clinical pathology (hematology, coagulation, clinical chemistry), or anatomic pathology (organ weight, abnormalities, microscopic). NOEL = 5,000 mg/kg-day (highest dose tested)	Brock et al., 2010	Guideline study (OECD 422).

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	In a 28-day inhalation (dust) study (6 hour/day, 5 days/week) in rats, a significantly increased absolute liver weight with hepatocytomegaly of centrilobular hepatocytes, increased absolute lung weights, and increased numbers of macrophages in the alveoli in both males and females were observed. There were no effects on body weight, signs of toxicity, urinalysis, hematology, clinical chemistry, or gross pathology. LOAEC = 0.64 mg/L (lowest concentration tested)	Occidental Chemical Corporation, 1992	Not specified as a guideline study, but follows general OECD guidelines.
	In a 90-day oral (dietary) study in rats, there were no significant treatment-related effects observed; no effects on body or organ weights, urinalysis, clinical chemistry or hematology; there was a non-significant increased absolute and relative liver weights that were not associated with histopathological lesions. NOAEL = 100,000 ppm (highest dose tested)	Occidental Chemical Corporation, 1992	Not specified as a guideline study, but follows general OECD guidelines.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		In a 28-day dermal exposure (5 day/week, on shaved abraded skin) study in rabbits, no significant treatment-related adverse effects were observed. No effects on body weights, urinalysis, hematology, clinical chemistry, gross pathology, or histopathology; a significant decrease in liver and ovary weights were reported in female rats, though there were no associated changes in absolute organ weights or histopathological effects.	Occidental Chemical Corporation, 1992	Not specified as a guideline study, but follows general OECD guidelines.
		NOAEL = 2,000 mg/kg-day (highest dose tested)		
		Potential for repeated dose effects (Estimated by analogy and bioaccumulation)	Professional judgment	Estimated based on the high potential for bioaccumulation and by analogy to observations on decaBDE where adverse effects were not present in 90-day studies but were expressed following chronic exposure in a NTP study.
Skin Sensitization		LOW: Bis(hexachlorocyclopentadieno) cyclooctane was not a skin sensitizer in one study of guinea pigs.		
	Skin Sensitization	Negative for skin sensitization, guinea pigs	Brett, 1975	Not specified as a guideline study, but follows general OECD guidelines (modified Buehler).
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		VERY LOW: Bis(hexachlorocyclopentadieno) cyclooctane is not an eye-irritant in rabbits.		
	Eye Irritation	Non-irritant, rabbit	Occidental Chemical Corporation, 1992	Not specified as a guideline study, but follows general OECD guidelines.
Dermal Irritation		LOW: Estimated not to cause dermal irritation based on expert judgment.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Dermal Irritation	Low potential for dermal irritation. (Estimated)	Expert judgment	Estimated based on expert judgment.
Endocrine Activity		No data located.		
				No data located.
Immunotoxicity		No potential immunotoxic effects identified by expert judgment.		
	Immune System Effects			No data located.
ECOTOXICITY				
ECOSAR Class		Vinyl/allyl halides		
Acute Toxicity		LOW: Estimated data suggest no effects at saturation (NES) for the acute aquatic toxicity endpoints; experimental study details provided are insufficient to assess the hazard of acute aquatic toxicity, but are consistent with this hazard call.		
Fish LC ₅₀		<i>Lepomis macrochirus</i> (bluegill) 96-hour TL ₅₀ ≥ 100 mg/L - highest dose tested (flow-through conditions) (Experimental)	IUCLID, 2003	Sufficient details were not available to assess the quality of this study (non-good laboratory practice (GLP), study was given a Klimish code of 3 - invalid).
		<i>Lepomis macrochirus</i> (bluegill) 96-hour TL ₅₀ ≥ 100 mg/L - highest dose tested (static conditions) (Experimental)	IUCLID, 2003	Sufficient details were not available to assess the quality of this study (non-GLP, study was given a Klimish code of 3 - invalid).
		Fish 96-hour LC ₅₀ = 1.89x10 ⁻⁶ mg/L (Estimated) ECOSAR: Vinyl/allyl halides	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the structure activity relationship (SAR) limitation for log K _{ow} of 5.0; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish 96-hour LC ₅₀ = 7.2x10 ⁻⁶ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid LC₅₀	Daphnid 96-hour LC ₅₀ = 2.07x10 ⁻⁸ mg/L (Estimated) ECOSAR: Vinyl/allyl halides	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints.
	Daphnid 96-hour LC ₅₀ = 1.27x10 ⁻⁵ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae Green Algae EC₅₀	Green algae 96-hour EC ₅₀ = 5.4x10 ⁻⁶ mg/L (Estimated) ECOSAR: Vinyl/allyl halides	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae 96-hour EC ₅₀ = 0.00025 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Chronic Aquatic Toxicity	LOW: Estimated data suggest NES for chronic aquatic toxicity endpoints.		
Fish ChV	Fish 30-day ChV = 1.31x10 ⁻⁸ mg/L (Estimated) ECOSAR: Vinyl/allyl halides	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.
	Fish 30-day ChV = 5.57x10 ⁻⁷ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid ChV	Daphnid ChV = 6.06×10^{-6} mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K_{ow} of 11 for this chemical exceeds the SAR limitation for log K_{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae ChV	Green algae ChV = 6.52×10^{-5} mg/L (Estimated) ECOSAR: Vinyl/allyl halides	ECOSAR version 1.11	Chemical may not be soluble enough to measure this predicted effect; the toxicity value was determined from a predicted SAR using established acute to chronic ratios (ACRs) and ECOSAR regression techniques; NES: the log K_{ow} of 11 for this chemical exceeds the SAR limitation for log K_{ow} of 8.0; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae ChV = 0.00049 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Chemical may not be soluble enough to measure this predicted effect; the toxicity value was determined from a predicted SAR using established ACRs and ECOSAR regression techniques; NES: the log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

ENVIRONMENTAL FATE

Transport	Based on the Level III fugacity models incorporating the available experimental property data, bis(hexachlorocyclopentadieno) cyclooctane is expected to partition primarily to soil. Bis(hexachlorocyclopentadieno) cyclooctane is expected to be immobile in soil based on its estimated K_{oc}. Estimated volatilization half-lives indicate that it will be slightly volatile from surface water. Volatilization from dry surface is also not expected based on its estimated vapor pressure. In the atmosphere, bis(hexachlorocyclopentadieno) cyclooctane is expected to exist solely in the particulate phase, based on its estimated vapor pressure. Particulates may be removed from air by wet or dry deposition.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Henry's Law Constant (atm-m ³ /mole)	7.4x10 ⁻⁶ (Estimated)	EPI	
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	EPI; EPA, 2004	Cutoff value for non-mobile compounds.
		4,500,000 (Measured)	IUCLID, 2003 (citing from Chou et al., 1979)	Insufficient details were reported to assess the quality of this nonguideline study; however the results are consistent with other high MW, highly halogenated compounds.
	Level III Fugacity Model	Air ≤1% (Estimated) Water = 5% Soil = 92% Sediment = 3%	EPI	
Persistence		VERY HIGH: The persistence for bis(hexachlorocyclopentadieno) cyclooctane is a result of experimental degradation studies and estimations based on quantitative structure activity relationships (QSARs). Studies with aerobic and anaerobic sewage-sludge microorganisms reported no biodegradation in 2-3 to 6 weeks, respectively. Bis(hexachlorocyclopentadieno) cyclooctane has low water solubility and hydrolysis is not expected to be an important fate process; the two allylic chlorines capable of hydrolysis are at bridgehead locations which renders them resistant to displacement. Photolysis is not expected to be an important removal process with a measured degradation rate of <10% after 168 hours. Compiled, these degradation endpoints suggest a half-life >180 days. Environmental monitoring data supports a designation of very high persistence. Bis(hexachlorocyclopentadieno) cyclooctane has been detected in many places, including remote Arctic and Antarctic locations.		
Water	Aerobic Biodegradation	0% degradation after 21 days; 0.001 and 100 mg/L bis(hexachlorocyclopentadieno) cyclooctane dilutions made in water inoculated with 2 mL/L settled sewage-sludge containing microorganisms (Measured)	IUCLID, 2003; Occidental Chemical Company, 2009	Adequate, nonguideline study.
		0% after 14 days; not readily biodegradable (Measured)	IUCLID, 2003; Occidental Chemical Company, 2009	Adequate, nonguideline study.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Volatilization Half-life for Model River	8 days (Estimated)	EPI	
	Volatilization Half-life for Model Lake	100 days (Estimated)	EPI	
Soil	Aerobic Biodegradation	<1% degradation after 2 weeks; OECD 301C measuring biochemical oxygen demand; 100 ppm bis(hexachlorocyclopentadieno) cyclooctane with 30 ppm activated sludge inoculum (Measured)	MITI, 1998	Adequate, guideline study.
	Anaerobic Biodegradation	Not probable (Anaerobic-methanogenic biodegradation probability model) (Estimated)	EPI	
		0% after 2-6 weeks; Using C-14 labeled bis(hexachlorocyclopentadieno) cyclooctane; with anaerobic sewage sludge inoculum (Measured)	IUCLID, 2003; Occidental Chemical Company, 2009	Nonguideline study; sufficient details were not available to assess the quality of this study.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	5.6 hours (Estimated)	EPI	
Reactivity	Photolysis	Half-life: >24 years (Measured) Reported as <10% after 168 hours	IUCLID, 2003	Adequate; nonguideline study.
	Hydrolysis	Not a significant fate process (Estimated)	Wolfe and Jeffers, 2000; Professional judgment	The substance does not contain functional groups that would be expected to hydrolyze readily under environmental conditions.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Environmental Half-life		>180 days (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.
Bioaccumulation		HIGH: Estimated BAF and available monitoring data suggest very high potential for bis(hexachlorocyclopentadieno) cyclooctane bioaccumulation.		
	Fish BCF	23 to 121 (carp) (Measured); 14 to 96 (bluegill) (Measured)	MITI, 1998	Guideline study measured at a water solubility of 0.0027 mg/L.
		1.97 at 96 hours to 7.02 at 48 hours <i>Lepomis macrochirus</i> (Measured)	IUCLID, 2003	Nonguideline study.
	BAF	23,000 (Estimated)	EPI	
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		Bis(hexachlorocyclopentadieno) cyclooctane was detected in the particulate phase of air samples at 6 locations in the Great Lakes region and Lake Erie and Lake Michigan sediment (Hoh et al., 2006); in Japanese industrial zones along the Pacific coast (Kubota, 1979); in Ottawa, Canada residential indoor dust samples (Zhu et al., 2007; Dodson, 2012); in indoor dust collected from an e-waste recycling area and two control areas (rural and urban) in South China (Zheng et al., 2010); and in atmosphere and seawater samples taken from East Greenland Sea and the northern and southern Atlantic, toward Antarctica (Moller et al., 2010, 2011).		
Ecological Biomonitoring		Bis(hexachlorocyclopentadieno) cyclooctane has been detected in archived fish (walleye) samples from Lake Erie (Hoh et al., 2006); Ring-Billed Gulls from Canada (Gentes et al., 2012); fish from Lake Winnipeg and Lake Ontario food webs; five different fish species in South Korea; and plasma of nestling bald eagles (Sverko et al., 2011 citing Tomy et al., 2007; Kang et al., 2009 and Venier et al., 2010).		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011). Bis(hexachlorocyclopentadieno) cyclooctane was measured in human hair and indoor dust collected from an e-waste recycling area and two control areas in South China (Zheng et al., 2010); it was detected in serum samples in Guiyu and Haojiang (Ren et al., 2009) and Laizhou Bay residents (He et al., 2013).		

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Bisphenol A Bis-(diphenyl phosphate), BAPP

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

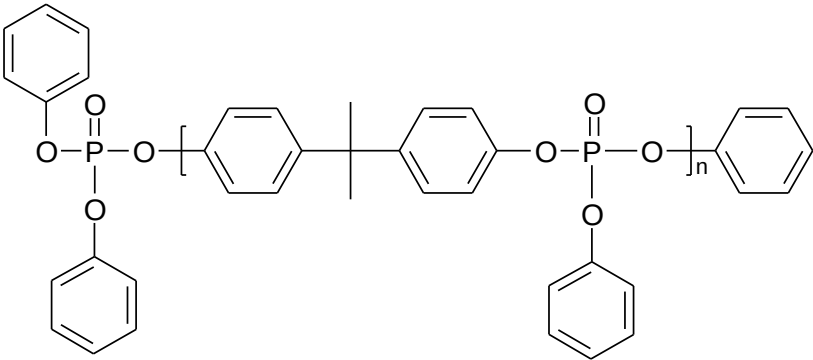
[§] Based on analogy to experimental data for a structurally similar compound.

[◇] The highest hazard designation of a representative component of the oligomeric mixture with MWs <1,000.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Bisphenol A Bis-(diphenyl phosphate); BAPP	181028-79-5	L	M	L	L	L [§]	L [§]	L	L		L	L	L	L	H	H [◇]

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

BAPP

	CASRN: 181028-79-5
	MW: 693 (n = 1); >1,000 (n = 2)
	MF: C ₃₉ H ₃₄ O ₈ P ₂ (n = 1; CASRN 5945-33-5)
	Physical Forms: Neat: Solid
	Use: Flame retardant
SMILES: c1(C(C)(C)c2ccc(OP(=O)(Oc3ccccc3)Oc3ccccc3)cc2)ccc(OP(=O)(Oc2ccccc2)Oc2ccccc2)cc1 (n = 1; CASRN 5945-33-5)	
Synonyms: Phosphoric trichloride, reaction products with bisphenol A and phenol; Phosphoric acid, isopropylidene di-p-phenylene tetraphenyl ester; 2,2-Bis[4-[bis(phenoxy)phosphoryloxy]phenyl]propane; 4,4'-(Isopropylidenediphenyl) bis(diphenyl phosphate); Bisphenol A bis(diphenyl phosphate); Bisphenol A tetraphenyl diphosphate; BADP; BDP; BPADP; Fyrolflex BDP; Phosphoric acid, P,P'-[(1-methylethylidene)di-4,1-phenylene] P,P,P',P'-tetraphenyl ester for 5945-33-5	
Chemical Considerations: This alternative is a polymer. The oligomer where n = 1 (also referred to as CASRN 5945-33-5) has a MW <1,000 and is amenable to EPI v4.0 estimation methods for physical/chemical and environmental fate values in the absence of experimental data. In commerce, CASRN 5945-33-5 is used interchangeably with 181028-79-5 and both represent in practice a substance that is 80+% BAPP with higher homologues (n=1, 2 or 3). Bisphenol A (CASRN 80-05-1), triphenyl phosphate (CASRN 115-86-6) and phenol (CASRN 108-95-2) are potential impurities in commercial formulations (NICNAS NA/773, 2000). The higher MW oligomers that have MWs >1,000 are assessed together using information contained in the literature concerning polymer assessment and professional judgment (Boethling et al., 1997).	

Polymeric: Yes	
Oligomers: The n = 1 structure comprises 80-85% of the mixture, with the balance primarily made up of higher oligomers (n = 2, 3, 4, etc.). The commercial mixture contains triphenyl phosphate as an impurity.	
Metabolites, Degradates and Transformation Products: None identified. Degradation of BAPP has been demonstrated in experimental studies (Iwami, 1994; Hogg, 1997; Armstrong and White, 1999); however the degradates have not been identified. Degradation of BAPP by sequential dephosphorylation could produce phenol (CASRN 108-95-2), diphenyl phosphate (CASRN 838-85-7), and bisphenol A (CASRN 80-05-1). The importance of dephosphorylation relative to possible competing pathways has not been demonstrated in a published study. Therefore the hazards of the theoretical degradation products were not considered in this hazard assessment.	
Analogs: Confidential compounds	Analog Structures: No structure provided for confidential compounds.
Endpoint(s) using analog values: Developmental effects; neurotoxicity	
Structural Alerts: None	
Risk Phrases: For CASRN 5945-33-5 R53 - May cause long-term adverse effects in the aquatic environment (ESIS, 2012; under review CLH, 2011).	
Hazard and Risk Assessments: Risk assessment completed for BAPP by the National Industrial Chemicals Notification and Assessment Scheme (NICNAS NA/869, 2000; NICNAS NA/773, 2000).	

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	41.3-68.6 (Measured)	Hogg, 1997; NICNAS NA/773, 2000	Results from differential scanning calorimetry analysis were originally reported as a boiling point range of 41.3-68.6°C in the NICNAS document. The melting point range is likely from a commercial product or mixture.
	7; OECD 102 (Measured)	Chemtura, 2011	Reported for oligomer where n=1 (CASRN 5945-33-5).
Boiling Point (°C)	>201 (decomposes) (Measured)	Hogg, 1997	Reported to decompose without boiling at temperatures above 201°C.
	>240 – 250 (Measured)	Lightbody, 1999	Inadequate; the reported data are for a commercial mixture.
	Decomposes above 350 without boiling; Organisation of Economic Cooperation and Development (OECD) 103 (Measured)	Chemtura, 2011	Reported for oligomer where n=1 (CASRN 5945-33-5).
Vapor Pressure (mm Hg)	<9×10 ⁻⁶ at 25°C (Extrapolated)	Tremain, 1997	Although a definitive value could not be reported in this study, the test chemical contained 1-3% triphenyl phosphate and residual phenol, which may have contributed to scatter in the data. These results suggest, however, that the EPI estimates for this endpoint are reasonable.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	2.1×10^{-8} (Estimated, n = 1)	EPI; Boethling et al., 1997	Although the higher MW oligomers are outside the domain of the available estimation methods, their vapor pressures are anticipated to be below the cutoff values.
	2.3×10^{-18} at 25°C (Extrapolated)	Tremain, 2000; Boethling et al., 1997	Inadequate; the data are for the commercial mixture extrapolated to 25°C. However, the data are consistent with a vapor pressure below the cutoff values for the higher MW oligomers.
	1×10^{-6} ; OECD 104 (Measured)	Chemtura, 2011	Reported for oligomer where n=1 (CASRN 5945-33-5).
Water Solubility (mg/L)	0.389 – 0.462 (Measured)	Hogg, 1997	Although the commercial mixture was likely used as test material, the reported value provides an upper boundary for the most soluble component of the mixture, the oligomer with n = 1. The experiment was performed in acidic conditions (pH 5.5-6) and the purity of the test chemical was not specified.
	$<10^{-3}$ (Estimated)	EPI; Boethling et al., 1997	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Although the higher MW oligomers are outside the domain of the available estimation methods, their water solubility values are anticipated to be below the cutoff values.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	<2x10 ⁻² (Measured)	Lightbody, 1999	Inadequate; the reported data are for a commercial mixture.
Log K_{ow}	>6 (Measured)	Iwami, 1995	The commercial mixture was likely used as test material; cutoff too low to address endpoints for the hazard assessment.
	>10 (Estimated)	EPI; Boethling et al., 1997	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Although the higher MW oligomers are outside the domain of the available estimation methods, their K _{ow} values are anticipated to be above the cutoff values.
	4.0 (n = 1); 5.2 (n = 2) (Measured)	Lightbody, 1999	Inadequate; the reported data are for a commercial mixture. The results are more consistent with the measured value for the triphenyl phosphate impurity (log K _{ow} =4.59) than with the BAPP oligomers.
	4.5, >4.9; OECD 107 (Measured)	Chemtura, 2011	Reported for oligomer where n=1 (CASRN 5945-33-5).
Flammability (Flash Point)	>300 (Measured)	NICNAS NA/773, 2000	Reported in a secondary source, study details and test conditions were not provided.
	>360, closed cup (Measured)	NICNAS NA/869, 2000	
	281; European Economic Community (EEC) method No A9 (Measured)	Chemtura, 2011	Reported for oligomer where n=1 (CASRN 5945-33-5).
Explosivity	Not explosive; EEC method No A14 (Measured)	Chemtura, 2011	Reported for oligomer where n=1 (CASRN 5945-33-5).
Pyrolysis			No data located.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pH		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
HUMAN HEALTH EFFECTS				
Toxicokinetics		Based on professional judgment, absorption is not expected for any route of exposure for the neat material. Poor absorption of the low MW fraction in solution can be expected in all routes.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption is expected for any route of exposure; poor absorption of low MW fraction (0% <500, 85% <1,000) in solution by all routes (Estimated by analogy)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
Acute Mammalian Toxicity		LOW: Based on oral and dermal LD ₅₀ values of >2,000 mg/kg in rats for both the commercial mixture and its predominant component. No data located regarding the acute inhalation hazard.		
Acute Lethality	Oral	Rat oral LD ₅₀ >2,000 mg/kg	NICNAS NA/869, 2000	Reported in a secondary source. Study conducted according to OECD guidelines (OECD 401). Data are for commercial mixture.
		Rat oral LD ₅₀ >2,000 mg/kg	NICNAS NA/773, 2000	Reported in a secondary source. Study conducted according to EEC/OECD guidelines (OECD 401). Data are for the predominant component.
	Dermal	Rat dermal LD ₅₀ >2,000 mg/kg	NICNAS NA/869, 2000	Reported in a secondary source. Study conducted according to EEC/OECD guidelines (OECD 402). Data are for commercial mixture.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Rat dermal LD ₅₀ >2,000 mg/kg	NICNAS NA/773, 2000	Reported in a secondary source. Study conducted according to EEC/OECD guidelines (OECD 402). Data are for the predominant component.
	Inhalation			No data located.
Carcinogenicity		MODERATE: BAPP may have low potential for carcinogenicity based on expert judgment; there were no structural alerts in the molecule. However, there is uncertainty regarding the carcinogenicity of BAPP due to the lack of data for this substance. Carcinogenic effects cannot be completely ruled out.		
	OncoLogic Results			No data located; not amenable to available estimation methods.
	Carcinogenicity (Rat and Mouse)	Low potential for carcinogenicity. (Estimated)	Expert judgment	Estimated based on expert judgment; no data located.
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: There is uncertain potential for mutagenicity based on experimental studies. Neither the commercial mixture nor the predominant component induced gene mutations in several <i>in vitro</i> assays in bacteria and did not induce chromosomal aberrations in Chinese hamster ovary (CHO) or Chinese hamster lung (CHL) cells <i>in vitro</i> . The commercial mixture did not increase micronucleated polychromatic erythrocytes in mouse bone marrow cells <i>in vivo</i> .		
	Gene Mutation <i>in vitro</i>	Negative, Ames assay (standard plate) in <i>Salmonella typhimurium</i> strains TA98, TA100, TA1537, TA1535, and <i>E. coli</i> WP2uvrA with and without metabolic activation	NICNAS NA/869, 2000	Sufficient study details were reported in a secondary source; used OECD test guidelines (OECD 471 & 472). Data are for commercial mixture.
		Negative, Ames assay (standard plate) in <i>Salmonella typhimurium</i> strains TA98, TA100, TA1537, TA1535, and <i>E. coli</i> WP2uvrA with and without metabolic activation	NICNAS NA/773, 2000	Sufficient study details were reported in a secondary source; used OECD test guidelines (OECD 471 & 472). Data are for the predominant component.
	Gene Mutation <i>in vivo</i>			No data located.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Chromosomal Aberrations <i>in vitro</i>	Uncertain potential for mutagenicity based on a positive result for chromosome aberrations in CHL cells (Estimated by analogy)	Professional judgment	Based on a structurally similar confidential analog.
		Negative, did not produce chromosomal aberrations in CHO cells with and without metabolic activation	NICNAS NA/869, 2000	Sufficient study details were reported in a secondary source; used OECD test guidelines (OECD 473). Data are for commercial mixture.
		Negative, did not produce chromosomal aberrations in CHL cells with and without metabolic activation	NICNAS NA/773, 2000	Sufficient study details were reported in a secondary source; used EC/EEC test guidelines (EC Directives 87/18/EEC and 88/320/EEC). Data are for the predominant component.
	Chromosomal Aberrations <i>in vivo</i>	Negative; did not increase micronucleated polychromatic erythrocytes in bone marrow cells of mice treated with 2,000 mg/kg at 0 and 24 hours. No mortalities or adverse effects were observed in treated animals.	NICNAS NA/869, 2000	Sufficient study details were reported in a secondary source; used OECD test guidelines (OECD 474). Data are for commercial mixture.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: Estimated to have low potential for reproductive effects based on expert judgment. No data located.		
	Reproduction/ Developmental Toxicity Screen	Low potential for reproductive effects. (Estimated)	Expert judgment	Estimated based on expert judgment.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Reproduction and Fertility Effects			
Developmental Effects		LOW: Estimated to have low potential for developmental effects based on a structurally similar confidential analog. No fetal effects reported. Experimental data located are inadequate to designate a hazard for this endpoint. Although predicted to have low hazard, there is high uncertainty due to lack of data related to developmental neurotoxicity.		
	Reproduction/ Developmental Toxicity Screen	Oral, developmental study; no fetal effects reported. (Estimated by analogy)	Professional judgment	Based on a structurally similar confidential analog.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development	14-day developmental study in rats via oral gavage NOAEL: 1,000 mg/kg-day	Illinois EPA, 2007; WA Department of Health, 2006	Insufficient study details reported in a secondary source. Data are for commercial mixture.
	Postnatal Development			No data located.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Neurotoxicity		LOW: Estimated based on analogy to phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol (BPBP). In one experimental study of BPBP, there were no neurotoxic effects observed at doses up to 1,000 mg/kg-day following 28-day oral administration of the commercial mixture to rats. This study was not designed to assess all neurological parameters; however, it supports the estimated Low hazard designation. Although low hazard is predicted, there is uncertainty due to lack of data on cholinesterase inhibition which is associated with phosphate esters.		
	Neurotoxicity Screening Battery (Adult)	In a 28-day oral (gavage) study of Sprague-Dawley rats, there were no treatment-related changes in any of the parameters measured (body weight gain, food consumption, clinical signs, organ weights, clinical chemistry, hematology, gross necropsy, histopathology). There were no notable neurotoxicological abnormalities reported in weekly evaluations. ≥1,000 mg/kg-day (highest dose tested)	NICNAS NA/869, 2000	Limited study details were reported for the neurotoxicity endpoint; it is unclear what neurological parameters were evaluated; it appears that this study was not designed to assess all neurological parameters; therefore neurotoxicity cannot be ruled out; used OECD test guidelines (OECD 407). Data are for commercial mixture.
		28-day oral (gavage) study NOAEL = 1,000 mg/kg (Estimated by analogy)	Confidential study submitted for analog and Professional judgment	Estimated based on analogy to phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol (CASRN 1003300-73-9).

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects		LOW: There were no treatment-related changes in systemic toxicity parameters measured at doses up to 1,000 mg/kg-day in a 28-day oral study in Sprague-Dawley rats. Although only one species has been studied, these were comprehensive OECD or EEC guideline studies that found no dose-related effects for either the commercial mixture or its predominant component.		
		In a 28-day oral (gavage) study in Sprague-Dawley rats, there were no treatment-related changes in any of the parameters measured (body weight gain, food consumption, clinical signs, neurotoxicology parameters, organ weights, clinical chemistry, hematology, gross necropsy, histopathology) NOEL $\geq$ 1,000 mg/kg-day (highest dose tested)	NICNAS NA/869, 2000	Sufficient study details were reported; used OECD test guidelines (OECD 407). Data are for commercial mixture.
		In a 28-day oral (gavage) study in Sprague-Dawley rats, there were no treatment-related changes in any of the parameters measured (clinical signs, organ weights, clinical chemistry, hematology, gross necropsy, histopathology) NOEL $\geq$ 1,000 mg/kg-day (highest dose tested)	NICNAS NA/773, 2000	Sufficient study details were reported; used EEC test guidelines (EEC Directive 92/69/EEC, Method B7). Data are for the predominant component.
	Immune System Effects	Low potential for immunotoxicity. (Estimated)	Expert judgment	Estimated based on expert judgment.
Skin Sensitization		LOW: Commercial mixture and its predominant component were not skin sensitizers in two studies of guinea pigs.		
	Skin Sensitization	Non-sensitizing, guinea pig	NICNAS NA/869, 2000	Conducted according to EEC/OECD guidelines (OECD 406). Data are for commercial mixture.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Non-sensitizing, guinea pig	NICNAS NA/773, 2000	Conducted according to EEC/OECD guidelines (OECD 406). Data are for the predominant component.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Commercial mixture was slightly irritating and predominant component was non-irritating to rabbit eyes.		
	Eye Irritation	Slightly irritating, rabbit	NICNAS NA/869, 2000	Conducted according to EEC/OECD guidelines (OECD 405). Data are for commercial mixture.
		Non-irritant, rabbit	NICNAS NA/773, 2000	Conducted according to EEC/OECD guidelines (OECD 405). Data are for the predominant component.
Dermal Irritation		LOW: Commercial mixture was slightly irritating and predominant component was non-irritating to rabbit skin.		
	Dermal Irritation	Slightly irritating, rabbit	NICNAS NA/869, 2000	Conducted according to EEC/OECD guidelines (OECD 404). Data are for commercial mixture.
		Non-irritant, rabbit	NICNAS NA/773, 2000	Conducted according to EEC/OECD guidelines (OECD 404). Data are for the predominant component.
Endocrine Activity		No experimental data were located to evaluate and determine if BAPP affects endocrine activity.		
		Low potential for endocrine activity. (Estimated)	Expert judgment	Estimated based on expert judgment.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Immunotoxicity		Estimated to have low potential for immunotoxicity based on expert judgment. No experimental data for this substance were located.		
	Immune System Effects	Low potential for immunotoxicity. (Estimated)	Expert judgment	Estimated based on expert judgment.
ECOTOXICITY				
ECOSAR Class				
Acute Toxicity		LOW: Experimental data for both the predominant component (n = 1) and the commercial mixture for fish, daphnia, and algae indicate no effects up to the limits of the water solubility. Estimates are consistent with NES.		
Fish LC ₅₀		<i>Oncorhynchus mykiss</i> (rainbow trout), 96-hour LC ₅₀ >0.025 mg/L NOEC = 0.025 mg/L (Experimental)	NICNAS NA/869, 2000	Conducted according to OECD guidelines (OECD 203); not toxic up to the limits of its water solubility.
		<i>Oncorhynchus mykiss</i> (rainbow trout), 96-hour LC ₅₀ >1 mg/L NOEC >1 mg/L (Experimental)	NICNAS NA/773, 2000	Conducted according to OECD guidelines (OECD 203); not toxic up to the limits of its water solubility. Data are for the predominant component.
		Fish 96-hour LC ₅₀ = NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimated data based on the high K _{ow} of the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Although the higher MW oligomers are outside the domain of the estimation method, they are also anticipated to display NES. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid LC ₅₀	<i>Daphnia magna</i> , 48-hour EC ₅₀ >0.034 mg/L; NOEC = 0.034 mg/L (immobilization) (Experimental)	NICNAS NA/869, 2000	Conducted according to OECD guidelines (OECD 202); not toxic up to the limits of its water solubility. Data are for commercial mixture.
	<i>Daphnia magna</i> , 48-hour EC ₅₀ >1 mg/L; NOEC >1 mg/L (immobilization) (Experimental)	NICNAS NA/773, 2000	Conducted according to OECD guidelines (OECD 202); not toxic up to the limits of its water solubility. Data are for the predominant component.
	Daphnid 48-hour LC ₅₀ = NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimated data based on the high K _{ow} of the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Although the higher MW oligomers are outside the domain of the estimation method, they are also anticipated to display NES. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Green Algae EC ₅₀	<i>Selenastrum subspicatus</i> 72-hour EbC ₅₀ >0.02 mg/L; NOEC = 0.02 mg/L (growth) (Experimental)	NICNAS NA/869, 2000	Conducted according to OECD guidelines (OECD 201); not toxic up to the limits of its water solubility. Data are for commercial mixture.
	<i>Selenastrum subspicatus</i> 72-hour EbC ₅₀ >1 mg/L; NOEC >1 mg/L (growth) (Experimental)	NICNAS NA/773, 2000	Conducted according to OECD guidelines (OECD 201); not toxic up to the limits of its water solubility. Data are for the predominant component.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae 96-hour LC ₅₀ = NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimated data based on the high K _{ow} of the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Although the higher MW oligomers are outside the domain of the estimation method, they are also anticipated to display NES. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Chronic Aquatic Toxicity	LOW: Experimental data for the commercial mixture in <i>Daphnia</i> indicate no toxicity effects up to the limits of the water solubility. Estimates for fish and algae also suggest no effects at saturation (NES).		
Fish ChV	Fish ChV = NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimated data based on the high K _{ow} of the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Although the higher MW oligomers are outside the domain of the estimation method, they are also anticipated to display NES. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid ChV	<i>Daphnia magna</i> , 21-day EC ₅₀ >0.02 mg/L; NOEC = 0.02 mg/L (reproduction test) (Experimental)	NICNAS NA/869, 2000	Conducted according to OECD guidelines (OECD 211); not toxic up to the limits of its water solubility. Data are for commercial mixture.
	Daphnia ChV = NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimated data based on the high K _{ow} of the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Although the higher MW oligomers are outside the domain of the estimation method, they are also anticipated to display NES. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Saltwater Invertebrate ChV			No data located.
Green Algae ChV	Green algae ChV = NES (Estimated) ECOSAR neutral organics	ECOSAR version 1.11	Estimated data based on the high K _{ow} of the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Although the higher MW oligomers are outside the domain of the estimation method, they are also anticipated to display NES. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The environmental fate is described using estimates on the lowest MW oligomer of BAPP, which is the predominant component. Based on the Level III fugacity models incorporating the available experimental property data, the lowest MW oligomer is expected to partition primarily to soil and sediment. BAPP is expected to be immobile in soil based on its estimated K_{oc} . Leaching of BAPP through soil to groundwater is not expected to be an important transport mechanism. Estimated volatilization half-lives indicate that BAPP will be nonvolatile from surface water. Volatilization from dry surface is also not expected based on its vapor pressure. In the atmosphere, BAPP is expected to exist solely in the particulate phase, based on its estimated vapor pressure. Particulates may be removed from air by wet or dry deposition. The higher MW components of the commercial mixture are anticipated to behave similarly to that described above.		
	Henry's Law Constant (atm-m ³ /mole)	Predominant component (5945-33-5): $<10^{-8}$ (Estimated)	EPI; Professional judgment	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture. The higher MW oligomers are also expected to have Henry's Law Constant values below this cutoff.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	$>3.39 \times 10^4$ (Measured)	Hogg, 1997	Data obtained using a high performance liquid chromatography (HPLC) method similar to OECD TGP/94.75 method. Although a commercial mixture was likely used as test material, the reported value provides a lower boundary for the most mobile component of the mixture, the oligomer with n = 1.
		Predominant component (5945-33-5): 30,000 (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Level III Fugacity Model	Air = <1% (Estimated) Water = 1.1% Soil = 42% Sediment = 57%	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.
Persistence		HIGH: Experimental studies were on the commercial mixture which is estimated to contain approximately 85% BAPP. BAPP is not readily biodegradable. In a Japanese Ministry of International Trade and Industry (MITI)-I (OECD Test TG 301C) test 6% biodegradation occurred over 28 days in sewage sludge. BAPP does not contain chromophores that absorb at wavelengths >290 nm, and therefore is not expected to be susceptible to direct photolysis by sunlight. The atmospheric half-life of BAPP is estimated to be 5.5 hours, although it is expected to exist primarily in the particulate phase in air. Enzymatic or basic hydrolysis leading to the production of phenol (CASRN 108-95-2), diphenyl phosphate (CASRN 838-85-7), and bisphenol A (CASRN 80-05-1) through sequential dephosphorylation is theoretically possible but has not been demonstrated.		
Water	Aerobic Biodegradation	Days-weeks (Primary survey model) Months (Ultimate survey model) (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.
		6% biodegradation detected after 28 days in activated sludge according to a MITI-I Ready Test (OECD TG 301C) (Measured)	Iwami, 1994	The commercial mixture was likely used as test material.
		2% biodegradation detected after 28 days in sewage sludge according to Ready Test Modified Sturm Test (OECD TG 301). (Measured)	Armstrong and White, 1999	The data are for the commercial mixture.
	Volatilization Half-life for Model River	>1 year (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Volatilization Half-life for Model Lake	>1 year (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation	Not probable (Anaerobic-methanogenic biodegradation probability model) (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	5.5 hours (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	>1 year at 25°C and pH 4.0, 7.0 and 9.0 (Measured)	Hogg, 1997	The commercial mixture was likely used as test material. Data indicate the resistance of the material to hydrolysis under environmental conditions. Purity of the test chemical was not specified.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		>1 year at pH 5 and pH 7; 6.3 days at pH 9 15 hours at pH 10 (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture. Hydrolysis rates are expected to be pH-dependent and may be limited by the low water solubility of this compound. Under basic conditions, sequential dephosphorylation reactions may occur.
Environmental Half-Life		>1 year (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology for the predominant oligomer component, n = 1, representing 85% of the commercial mixture.
Bioaccumulation		HIGH: Although measured BCF values for the components of the polymeric mixture result in a Moderate bioaccumulation hazard designation, the overall bioaccumulation designation for BAPP is high based on an estimated BAF value. The estimated BAF of 1,100 for the predominant component of the mixture with a MW <1,000 daltons, suggests that BAPP may bioaccumulate in higher trophic levels.		
	Fish BCF	≤100 (Measured) According to a method equivalent to OECD 305C in <i>Cyprinus carpio</i> with HPLC analysis of the n=1, n=2 and n=3 components BCF range: 6.8 – 62	Submitted confidential study	Although the commercial mixture was used as the test material, the BCF for each individual oligomer was measured.
		BCF range: ≤1.1 - ≤159 BCF range: 6.8 – 62 (Estimated by analogy)	Chemtura, 2011	Reported for oligomer where n=1 CASRN 5945-33-5.

Bisphenol A Bis-(diphenyl phosphate) CASRN 181028-79-5 and 5945-33-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		66 (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.
	BAF	1,100 (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 85% of the commercial mixture.
	Metabolism in fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Brominated Epoxy Polymers

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

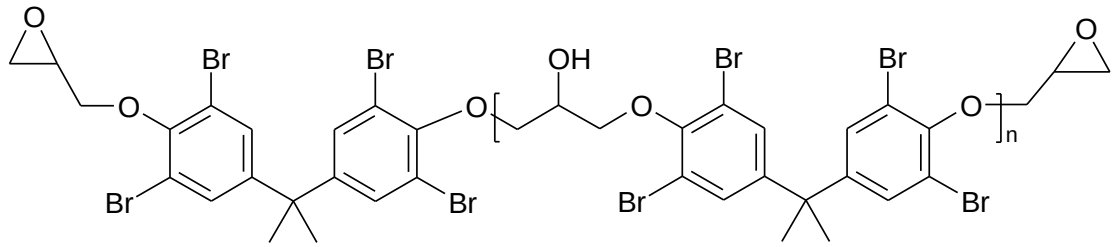
^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

♦ Different formulations of the commercial product are available. One of these many formulations has an average MW of ~1,600 and contains significant amounts of lower MW components. These lower MW components have hazard potentials different than the polymeric flame retardant, as follows: HIGH estimated potential for bioaccumulation; HIGH experimental for acute aquatic toxicity; HIGH estimated for chronic aquatic toxicity; MODERATE experimental for developmental toxicity; and MODERATE estimated for carcinogenicity, repeated dose, reproductive, and respiratory sensitization toxicity.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Brominated Epoxy Polymers	68928-70-1	<i>L</i>	<i>L</i> ♦	<i>L</i>	<i>L</i> ♦	<i>L</i> ♦	<i>L</i>	<i>L</i> ♦ ^d	<i>L</i>	♦	<i>L</i>	<i>L</i>	<i>L</i> ♦	<i>L</i> ♦	<i>VH</i>	<i>L</i> ♦

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Brominated Epoxy Polymers

		CASRN: 68928-70-1
		MW: 10,000 to >50,000; 0% <1,000
		MF: (C ₂₁ H ₂₀ Br ₄ O ₄ ·C ₁₅ H ₁₂ Br ₄ O ₂) _n
		Physical Forms:
		Neat: Solid
		Use: Flame retardant
SMILES: The polymer component with MW >1,000 is not amenable to SMILES notation.		
Synonyms: Phenol, 4,4'-(1-methylethylidene)bis[2,6-dibromo-, polymer with 2,2'-[(1-methylethylidene)bis[(2,6-dibromo-4,1-phenylene)oxymethylene]]bis[oxirane]; 4,4'-propane-2,2-diylbis(2,6-dibromophenol) - 2,2'-{propane-2,2-diylbis[(2,6-dibromobenzene-4,1-diyl)oxymethanediyl]}dioxirane (1:1); Tetrabromobisphenol A - Tetrabromobisphenol A diglycidyl ether polymer; Tetrabromobisphenol A, 2,2-bis(4-(2,3-epoxypropyloxy)dibromophenyl)propane polymer		
Chemical Considerations: This alternative is a high MW polymer. The extent of polymerization and thus average MW is formulation dependent. The higher MW oligomers, with a MW >1,000, are assessed together using professional judgment and information contained in the literature concerning polymer assessment (Boethling et al., 1997). However, it should be noted that at least one formulation of CASRN 68928-70-1 has a number average molecular weight (MW _n) of 1,600 with 12.7% <1,000 resulting from the presence of unchanged starting materials. The summary of the hazards of these unchanged starting materials, if present in the commercial formulation, are provided in Table 4-4 as a footnote (♦).		
Polymeric: Yes		
Oligomers: Commercial brominated epoxy polymer products represented by CASRN 68928-70-1 typically are comprised of high MW epoxy-terminated oligomers.		
Metabolites, Degradates and Transformation Products: None		
Analog: No analog		Analog Structure: Not applicable
Endpoint(s) using analog values: Not applicable		
Structural Alerts: None identified		
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).		
Hazard and Risk Assessments: None identified		

Brominated Epoxy Polymers CASRN 68928-70-1			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	135–150 (Measured)	ICL Industrial Products, 2011	For the commercial product F-2300H. The melting points reported cover a broad range and are anticipated to be formulation specific liquid-glass transition temperatures.
	105-115; 150 ± 5 (Measured)	NICNAS, 2001	For the commercial product F-2300H. The melting points reported cover a broad range and are anticipated to be formulation specific liquid-glass transition temperatures.
Boiling Point (°C)	>300 (Estimated)	Professional judgment	Cutoff value used for large, high MW solids.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
	Insoluble (Measured)	ICL Industrial Products, 2011; NICNAS, 2001	For the commercial product F-2300H; qualitative value that cannot be used to evaluate other endpoints within the hazard assessment.
Log K _{ow}			No data located; polymers with a MW >1,000 are outside the domain of the available estimation methods.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.

Brominated Epoxy Polymers CASRN 68928-70-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pH		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
HUMAN HEALTH EFFECTS				
Toxicokinetics		There is no absorption expected for any route of exposure. This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore is not expected to be readily absorbed, distributed or metabolized in the body. However, there are formulations of the commercial product available that may contain significant amounts of lower MW components; absorption may occur more readily in this case.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral	No absorption is expected for any route of exposure (Estimated)	Professional judgment	Estimated based on professional judgment.
Acute Mammalian Toxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for acute mammalian toxicity.		
Acute Lethality	Oral	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Dermal			
	Inhalation			
Carcinogenicity		LOW: This polymer is large, with a MW >1,000. It is expected to have few to no residual monomers, crosslinking, swellability, dispersability, potential for inhalation, nor hindered amine groups and therefore has low potential for carcinogenicity.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Chronic Toxicity/ Carcinogenicity			

Brominated Epoxy Polymers CASRN 68928-70-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Genotoxicity		LOW: Brominated Epoxy Polymers were not mutagenic in bacteria and did not cause chromosomal aberrations in human lymphocytes. In addition, these polymers are large, with a MW >1,000. They are expected to have limited bioavailability and therefore low potential for genotoxicity.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
		Negative, <i>Salmonella typhimurium</i> strains TA1535, TA1537, TA98 and TA100 and <i>Escherichia coli</i> strain WP2uvrA with and without metabolic activation.	Submitted confidential study	Reported in a submitted confidential study; Study conducted in accordance with Good laboratory practice (GLP) and Organisation of Economic Cooperation and Development (OECD) principles.
	Gene Mutation <i>in vivo</i>			
	Chromosomal Aberrations <i>in vitro</i>	Negative, chromosomal aberrations in human lymphocytes with and without metabolic activation. Test material was considered to be non-clastogenic.	Submitted confidential study	Reported in a submitted confidential study; Study conducted in accordance with GLP and OECD principles.
	Chromosomal Aberrations <i>in vivo</i>			
	DNA Damage and Repair			
	Other (Mitotic Gene Conversion)			
Reproductive Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for reproductive effects.		
	Reproduction/ Developmental Toxicity Screen			
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.

Brominated Epoxy Polymers CASRN 68928-70-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Reproduction and Fertility Effects			
Developmental Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for developmental effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for neurotoxicity.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW _n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations.		
		This polymer MW _n is >10,000; potential for irreversible lung damage as a result of lung overloading (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Skin Sensitization		LOW: Not a skin sensitizer in a local lymph node assay in mice.		
	Skin Sensitization	Low potential for skin sensitization. (Estimated)	Expert judgment	Estimated based on expert judgment.
		Not sensitizing, local lymph node assay in mice; application of test substance to the dorsal surface of the ear	Submitted confidential study	Reported in a submitted confidential study; Study conducted in accordance with GLP and OECD guideline 429 (“Skin Sensitization: Local Lymph Node Assay”).

Brominated Epoxy Polymers CASRN 68928-70-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Estimated not to have potential for eye irritation based on expert judgment. No data located.		
	Eye Irritation	Low potential for skin sensitization. (Estimated)	Expert judgment	Estimated based on expert judgment.
Dermal Irritation		LOW: Estimated not to have potential for dermal irritation based on expert judgment. No data located.		
	Dermal Irritation	Low potential for skin sensitization. (Estimated)	Expert judgment	Estimated based on expert judgment.
Endocrine Activity		This polymer is large, with a MW >1,000. It is not expected to have endocrine activity due to its poor bioavailability and inability to be readily metabolized in the body.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Immunotoxicity		This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for immunotoxicity.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Non-ionic polymers with a MW >1,000 and negligible water solubility are estimated to display no effects at saturation (NES). These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for those materials that display NES.		
Fish LC₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

Brominated Epoxy Polymers CASRN 68928-70-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Daphnid LC ₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae EC ₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity		LOW: Non-ionic polymers with a MW >1,000 and negligible water solubility are estimated to display NES. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for those materials that display NES.		
Fish ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that this polymer is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of <10⁻⁸ atm-m³/mole indicates that it is not expected to volatilize from water to the atmosphere. The estimated K_{oc} of >30,000 indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.

Brominated Epoxy Polymers CASRN 68928-70-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to adsorb strongly to soil and sediment.
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: This polymer is large, with a MW >1,000. It is expected to have negligible water solubility and poor bioavailability to microorganisms indicating that neither biodegradation nor hydrolysis are expected to be important removal processes in the environment. Although debromination by photodegradation of polybrominated benzenes has been observed, this process is not anticipated to lead to ultimate removal of the material. As a result, a half-life for this high MW polymer of >180 days leads to a potential for very high persistence.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Professional judgment	Bromine substituents may be susceptible to photolysis in the environment; however, this is expected to be a relatively slow process for a high MW brominated

Brominated Epoxy Polymers CASRN 68928-70-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
				epoxy polymer and is not anticipated to result in the ultimate degradation of this substance.
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.
Environmental Half-Life		>180 days (Estimated)	Professional judgment	The substance is a high MW polymer and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to undergo removal by other degradative processes under environmental conditions.
Bioaccumulation		LOW: Due to the large size and limited bioavailability of the high MW brominated epoxy polymer, it has low potential for bioconcentration or bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW, insoluble polymers.
	BAF			No data located.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

Boethling, Robert S. and Nabholz, J. Vincent “Environmental Assessment of Polymers under the U.S. Toxic Substances Control Act”, pp. 187-234, in Ecological Assessment of Polymers Strategies for Product Stewardship and Regulatory Programs, Hamilton, John D. and Sutcliffe, Roger (eds.), (1997) Van Nostrand Reinhold.

CDC (Centers for Disease Control and Prevention). *Fourth national report on human exposure to environmental chemicals, updated tables*. Department of Health and Human Services. **2011**. http://www.cdc.gov/exposurereport/pdf/Updated_Tables.pdf (accessed on May 10, 2011).

ESIS (European chemical Substances Information System) Classification, labeling and packaging of dangerous substances annex VI to regulation (EC) No 1272/2008 [Online]. <http://ecb.jrc.ec.europa.eu/esis/index.php?PGM=cla> (accessed on May 10, **2011**).

ICL Industrial Products. *F-2300H*. Brominated Epoxy Polymer MSDS. [http://www.icl-ip.com/brome/brome.nsf/viewAllByUNID/6A59162E67EFC8E2C225702900511DB6/\\$file/9223_enF-2300H.pdf](http://www.icl-ip.com/brome/brome.nsf/viewAllByUNID/6A59162E67EFC8E2C225702900511DB6/$file/9223_enF-2300H.pdf) (accessed on July 1, **2011**).

NICNAS (National Industrial Chemicals Notification and Assessment Scheme). Polybrominated flame retardants (PBFRs). Priority Existing Chemical Assessment Report No. 20. National Industrial Chemicals Notification and Assessment Scheme, June **2001**.

Brominated Epoxy Polymer(s)

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame-retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

♦ Different formulations of the commercial product are available. One of these many formulations has an average MW of ~1,600 and contains significant amounts of lower MW components. These lower MW components have hazard potentials different than the polymeric flame retardant, as follows: HIGH estimated potential for bioaccumulation; HIGH experimental for acute aquatic toxicity; HIGH estimated potential for chronic aquatic toxicity; MODERATE experimental for developmental; and MODERATE estimated for carcinogenicity, genotoxicity, repeated dose and reproductive toxicity, and skin and respiratory sensitization.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Brominated Epoxy Polymer(s)	Confidential	<i>L</i>	<i>L</i> ♦	<i>L</i> ♦	<i>L</i> ♦	<i>L</i> ♦	<i>L</i>	<i>L</i> ♦ ^d	<i>L</i> ♦	♦	<i>L</i>	<i>L</i>	<i>L</i> ♦	<i>L</i> ♦	<i>VH</i>	<i>L</i> ♦

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Brominated Epoxy Polymer(s)

	CASRN: Confidential CASRNs
	MW: Average MW 40,300; <5% MW <1,000 (for Polyquel 241)
	Average MW 50,000; 0% MW <1,000 (for Polyquel 240)
	MF: Confidential MFs
	Physical Forms: Neat: Solid
	Use: Flame retardant
SMILES: These confidential materials are not amenable to the generation of a single SMILES notation.	
Synonyms: Polyquel 240, Brominated epoxy polymer; Polyquel 241, Brominated epoxy polymer, containing low MW components	
Chemical Considerations: This alternative is a polymer; the majority of this polymer is comprised of high MW oligomers. The higher MW oligomers, with a MW >1,000, are assessed together using professional judgment and information contained in the literature concerning polymer assessment (Boethling et al., 1997). However, for some formulations it should be noted that <5% of this commercial product consists of components with a MW <1,000. A summary of the hazards of the MW <1,000 materials are provided in Table 4-4 as a footnote (♦).	
Polymeric: Yes Oligomers: Polyquel 241: The majority of this confidential commercial product (>95%) is comprised of high MW epoxy-terminated oligomers. Polyquel 240: The confidential commercial product is comprised of only high MW epoxy-terminated oligomers.	
Metabolites, Degradates and Transformation Products: None	
Analog: Confidential Endpoint(s) using analog values: Boiling point	Analog Structure: Not applicable
Structural Alerts: None identified	
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).	
Hazard and Risk Assessments: None identified	

Brominated Epoxy Polymer(s)			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	145-155 (Measured)	Warmington, 2010	Formulation specific liquid-glass transition temperatures for the commercial products Polyquel 240 and Polyquel 241.
Boiling Point (°C)	Decomposes (Estimated)	Submitted Confidential Study	Based on analogy to a confidential polymer with a similar structure and functional groups.
	>300 (Estimated)	Professional judgment	Cutoff value used for large, high MW solids.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; EPA, 1999	Cutoff value for large, high MW non-ionic polymers according to HPV polymer assessment guidance.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	Professional judgment; EPA, 1999	Cutoff value for large, high MW non-ionic polymers according to HPV polymer assessment guidance.
Log K _{ow}			No data; polymers with a MW >1,000 are outside the domain of the available estimation methods.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Brominated Epoxy Polymer(s)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		There is no absorption expected for any route of exposure. This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore is not expected to be readily absorbed, distributed or metabolized in the body. However, there are formulations of the commercial product available that may contain significant amounts of lower MW components; absorption may occur more readily in this case.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral	No absorption is expected for any route of exposure (Estimated)	Professional judgment	Estimated based on professional judgment.
Acute Mammalian Toxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for acute mammalian toxicity.		
Acute Lethality	Oral	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Dermal			
	Inhalation			
Carcinogenicity		LOW: This polymer is large, with a MW >1,000. It is expected to have few to no residual monomers, crosslinking, swellability, dispersability, potential for inhalation, nor hindered amine groups and therefore has low potential for carcinogenicity.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for genotoxicity.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Gene Mutation <i>in vivo</i>			
	Chromosomal Aberrations <i>in vitro</i>			
	Chromosomal Aberrations <i>in vivo</i>			

Brominated Epoxy Polymer(s)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	DNA Damage and Repair			
	Other (Mitotic Gene Conversion)			
Reproductive Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for reproductive effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for developmental effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for neurotoxicity.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.

Brominated Epoxy Polymer(s)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW_n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations.		
		This polymer MW _n is >10,000; potential for irreversible lung damage as a result of lung overloading (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Skin Sensitization		LOW: Estimated not to have potential for skin sensitization based on expert judgment. No data located.		
	Skin Sensitization	Low potential for skin sensitization. (Estimated)	Expert judgment	Estimated based on expert judgment.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Estimated not to have potential for eye irritation based on expert judgment. No data located.		
	Eye Irritation	Low potential for skin sensitization. (Estimated)	Expert judgment	Estimated based on expert judgment.
Dermal Irritation		LOW: Estimated not to have potential for dermal irritation based on expert judgment. No data located.		
	Dermal Irritation	Low potential for skin sensitization. (Estimated)	Expert judgment	Estimated based on expert judgment.
Endocrine Activity		This polymer is large, with a MW >1,000. It is not expected to have endocrine activity due to its poor bioavailability and inability to be readily metabolized in the body.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Immunotoxicity		This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for immunotoxicity.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Non-ionic polymers with a MW >1,000 and negligible water solubility are estimated to display no effects at saturation (NES). These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for those materials that display NES.		

Brominated Epoxy Polymer(s)			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Fish LC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid LC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae EC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity	LOW: Non-ionic polymers with a MW >1,000 and negligible water solubility are estimated to display NES. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for those materials that display NES.		
Fish ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

Brominated Epoxy Polymer(s)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that this polymer is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of $<10^{-8}$ atm-m ³ /mole indicates that it is not expected to volatilize from water to the atmosphere. The estimated K _{oc} of >30,000 indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m³/mole)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to adsorb strongly to soil and sediment.
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: This polymer is large, with a MW >1,000. It is expected to have negligible water solubility and poor bioavailability to microorganisms indicating that neither biodegradation nor hydrolysis are expected to be important removal processes in the environment. Although debromination by photodegradation of polybrominated benzenes has been observed, this process is not anticipated to lead to ultimate removal of the material. As a result, a half-life for this high MW polymer of >180 days leads to a potential for very high persistence.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.

Brominated Epoxy Polymer(s)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Professional judgment	Bromine substituents may be susceptible to photolysis in the environment; however, this is expected to be a relatively slow process for a high MW brominated epoxy polymer and is not anticipated to result in the ultimate degradation of this substance.
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.
Environmental Half-Life		>180 days (Estimated)	Professional judgment	The substance is a high MW polymer and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to undergo removal by other degradative processes under environmental conditions.
Bioaccumulation		LOW: Due to the large size and limited bioavailability of the polymer, it is of low potential for bioconcentration or bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW, insoluble polymers.
	BAF			No data located.

Brominated Epoxy Polymer(s)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

Boethling, Robert S. and Nabholz, J. Vincent “Environmental Assessment of Polymers under the U.S. Toxic Substances Control Act”, pp. 187-234, in Ecological Assessment of Polymers Strategies for Product Stewardship and Regulatory Programs, Hamilton, John D. and Sutcliffe, Roger (eds.), (1997) Van Nostrand Reinhold.

CDC (Centers for Disease Control and Prevention). *Fourth national report on human exposure to environmental chemicals, updated tables*. Department of Health and Human Services. **2011**. http://www.cdc.gov/exposurereport/pdf/Updated_Tables.pdf (accessed on May 10, 2011).

EPA (Environmental Protection Agency). High Production Volume (HPV) Challenge. Determining the Adequacy of Existing Data. U.S. Environmental Protection Agency: Washington D.C. 1999. <http://www.epa.gov/hpv/pubs/general/datadfin.htm>

ESIS (European chemical Substances Information System) Classification, labeling and packaging of dangerous substances annex VI to regulation (EC) No 1272/2008 [Online]. <http://ecb.jrc.ec.europa.eu/esis/index.php?PGM=cla> (accessed on May 10, 2011).

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Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

♦ Different formulations of the commercial product are available. One of these many formulations has an average MW of ~1,600 and contains significant amounts of lower MW components. These lower MW components have hazard potentials different than the polymeric flame retardant, as follows: HIGH estimated potential for bioaccumulation; HIGH experimental for acute aquatic toxicity; HIGH estimated for chronic aquatic toxicity; MODERATE experimental for developmental; and MODERATE estimated for carcinogenicity, genotoxicity, repeated dose and reproductive toxicity, and skin and respiratory sensitization.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Mixture of brominated epoxy polymer(s) and bromobenzyl acrylate	Confidential	<i>L</i>	<i>L</i> ♦	<i>L</i> ♦	<i>L</i> ♦	<i>L</i> ♦	<i>L</i>	<i>L</i> ♦ ^d	<i>L</i> ♦	♦	<i>L</i>	<i>L</i>	<i>L</i> ♦	<i>L</i> ♦	<i>VH</i>	<i>L</i> ♦

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate

		CASRN: Confidential CASRNs
		MW: Average MW 61,200; <1% MW <1,000 (Polyquel 145)
		Average MW 45,000; <2% MW <1,000 (Polyquel 146)
		MF: Confidential MFs
		Physical Forms: Neat: Solid
		Use: Flame retardant
SMILES: These mixtures containing confidential material are not amenable to the generation of a single SMILES notation.		
Synonyms: Polyquel 145, Mixture of brominated epoxy polymers and bromobenzyl acrylate homopolymer; Polyquel 146, Mixture of brominated epoxy polymer and bromobenzyl acrylate homopolymer		
Chemical Considerations: These alternatives are confidential mixtures comprised of high MW polymers. All components are high MW oligomers, with a MW >1,000, and are assessed using professional judgment and information contained in the literature concerning polymer assessment (Boethling et al., 1997). The final hazard evaluation, presented in Table 4-4, is based on the most hazardous material typically present in the commercial product, using a conservative approach. Polyquel 145 contains <1% of components with a MW <1,000. Polyquel 146 contains <2% of components with a MW <1,000. A summary of the hazards of the MW <1,000 materials are provided in Table 4-4 as a footnote (♦).		
Polymeric: Yes Oligomers: These commercial products are confidential mixtures comprised of two or three high MW polymers: a brominated epoxy polymer, a brominated polyacrylate and for Polyquel 145, an end capped brominated epoxy polymer.		
Metabolites, Degradates and Transformation Products: None		
Analog: Confidential Endpoint(s) using analog values: Boiling point		Analog Structure: Confidential structure
Structural Alerts: None identified		
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).		
Hazard and Risk Assessments: None identified		

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)			No data located.
Boiling Point (°C)	Decomposes (Estimated)	Professional judgment	Based on analogy to a confidential polymer with a similar structure and functional groups.
	>300 (Estimated)	Professional judgment	Cutoff value used for large, high MW solids.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
Log K_{ow}			No data located. Polymers with a MW >1,000 are outside the domain of the available estimation methods.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	This polymer mixture does not contain functional groups that would be expected to ionize.
pK_a	Not applicable	Professional judgment	This polymer mixture does not contain functional groups that would be expected to ionize.

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		There is no absorption expected for any route of exposure. These polymers are large, with MW >1,000. They are expected to have limited bioavailability and therefore are not expected to be readily absorbed, distributed or metabolized in the body.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral	No absorption is expected for any route of exposure (Estimated)	Professional judgment	Estimated based on professional judgment.
Acute Mammalian Toxicity		LOW: These polymers are large, with MW >1,000. They are expected to have limited bioavailability and therefore have low potential for acute mammalian toxicity.		
Acute Lethality	Oral	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Dermal			
	Inhalation			
Carcinogenicity		LOW: These polymers are large, with MW >1,000. They are expected to have few to no residual monomers, crosslinking, swellability, dispersability, potential for inhalation, nor hindered amine groups and therefore have low potential for carcinogenicity.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: These polymers are large, with MW >1,000. They are expected to have limited bioavailability and therefore have low potential for genotoxicity.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Gene Mutation <i>in vivo</i>			
	Chromosomal Aberrations <i>in vitro</i>			
	Chromosomal Aberrations <i>in vivo</i>			
	DNA Damage and Repair			

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Other (Mitotic Gene Conversion)			
Reproductive Effects		LOW: These polymers are large, with MW >1,000. They are expected to have limited bioavailability and therefore have low potential for reproductive effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		LOW: These polymers are large, with MW >1,000. They are expected to have limited bioavailability and therefore have low potential for developmental effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: These polymers are large, with MW >1,000. They are expected to have limited bioavailability and therefore have low potential for neurotoxicity.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW_n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations.		
		The polymer mixture MW _n is >10,000; potential for irreversible lung damage as a result of lung overloading (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Skin Sensitization		LOW: Estimated not to have potential for skin sensitization based on expert judgment. No data located.		
	Skin Sensitization	Low potential for skin sensitization. (Estimated)	Expert judgment	Estimated based on expert judgment.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Estimated not to have potential for eye irritation based on expert judgment. No data located.		
	Eye Irritation	Low potential for eye irritation. (Estimated)	Expert judgment	Estimated based on expert judgment.
Dermal Irritation		LOW: Estimated not to have potential for dermal irritation based on expert judgment. No data located.		
	Dermal Irritation	Low potential for dermal irritation. (Estimated)	Expert judgment	Estimated based on expert judgment.
Endocrine Activity		These polymers are large, with MW >1,000. They are not expected to have endocrine activity due to poor bioavailability and inability to be readily metabolized in the body.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Immunotoxicity		These polymers are large, with MW >1,000. They are expected to have limited bioavailability and therefore have low potential for immunotoxicity.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Non-ionic polymers with a MW >1,000 and negligible water solubility are estimated to display no effects at saturation (NES). These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for those materials that display NES.		

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Fish LC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid LC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae EC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity	LOW: Non-ionic polymers with a MW >1,000 and negligible water solubility are estimated to display NES. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for those materials that display NES.		
Fish ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that these polymers are anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of $<10^{-8}$ atm-m ³ /mole indicates that they are not expected to volatilize from water to the atmosphere. The estimated K _{oc} of >30,000 indicates that they are not anticipated to migrate from soil into groundwater and also have the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m ³ /mole)	$<10^{-8}$ (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to adsorb strongly to soil and sediment.
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: These polymers are large, with MW >1,000. They are expected to have negligible water solubility and poor bioavailability to microorganisms indicating that neither biodegradation nor hydrolysis are expected to be important removal processes in the environment. Although debromination by photodegradation of polybrominated benzenes has been observed, this process is not anticipated to lead to ultimate removal of the material. As a result, a half-life for these high MW polymer of >180 days leads to a potential for very high persistence.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation with Product Identification			No data located.

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Professional judgment	Bromine substituents may be susceptible to photolysis in the environment; however, this is expected to be a relatively slow process for a high MW brominated epoxy polymer and is not anticipated to result in the ultimate degradation of this substance.
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.
Environmental Half-Life		>180 days (Estimated)	Professional judgment	The substance is a high MW polymer and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to undergo removal by other degradative processes under environmental conditions.
Bioaccumulation		LOW: Due to the large size and limited bioavailability of the high MW polymer mixtures, they have low potential for bioconcentration or bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW, insoluble polymers.
	BAF			No data located.
	Metabolism in Fish			No data located.

Mixture of Brominated Epoxy Polymer(s) and Bromobenzyl Acrylate			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL MONITORING AND BIOMONITORING			
Environmental Monitoring	No data located.		
Ecological Biomonitoring	No data located.		
Human Biomonitoring	This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

Boethling, Robert S. and Nabholz, J. Vincent “Environmental Assessment of Polymers under the U.S. Toxic Substances Control Act”, pp. 187-234, in Ecological Assessment of Polymers Strategies for Product Stewardship and Regulatory Programs, Hamilton, John D. and Sutcliffe, Roger (eds.), (1997) Van Nostrand Reinhold.

CDC (Centers for Disease Control and Prevention). *Fourth national report on human exposure to environmental chemicals, updated tables*. Department of Health and Human Services. **2011**. http://www.cdc.gov/exposurereport/pdf/Updated_Tables.pdf (accessed on May 10, 2011).

ESIS (European chemical Substances Information System) Classification, labeling and packaging of dangerous substances annex VI to regulation (EC) No 1272/2008 [Online]. <http://ecb.jrc.ec.europa.eu/esis/index.php?PGM=cla> (accessed on May 10, 2011).

Brominated Epoxy Resin End-Capped with Tribromophenol

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

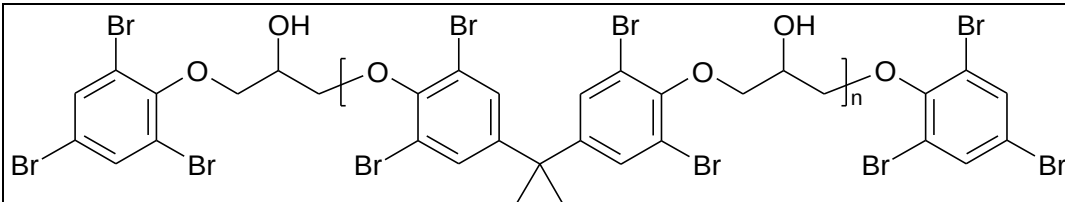
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Brominated Epoxy Resin End-Capped with Tribromophenol	135229-48-0	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i> ^d	<i>L</i>		<i>L</i>	<i>VL</i>	<i>L</i>	<i>L</i>	<i>VH</i>	<i>L</i>

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Brominated Epoxy Resin End-Capped with Tribromophenol



CASRN: 135229-48-0

MW: 15,000; 0% <1,000

MF: $(C_{15}H_{12}Br_4O_2 \cdot C_6H_3Br_3O \cdot C_3H_5ClO)_n$

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: This polymer with MW >1,000 and no low MW components is not amenable to SMILES notation.

Synonyms: 2,2'-[(1-Methylethylidene)bis[(2,6-dibromo-4,1-phenylene)oxymethylene]]bisoxirane polymer with 2,2',6,6'-tetrabromo-4,4'-isopropylidenediphenol and 2,4,6-tribromophenol; Phenol, 4,4'-(1-methylethylidene)bis[2,6-dibromo-, polymer with (chloromethyl)oxirane and 2,4,6-tribromophenol

Chemical Considerations: This alternative is a polymer. The extent of polymerization and thus average MW is formulation dependent. The higher MW oligomers with a MW >1,000 are assessed together using information contained in the literature concerning polymer assessment and professional judgment (Boethling et al., 1997). Additionally, lower MW formulations of brominated epoxy resin end-capped with tribromophenol exist and the simplest oligomer, comprised of each monomer, has a MW of 970. Although below the cutoff of 1,000 used in the polymer assessment criteria, this oligomer is anticipated to possess physical/chemical properties similar to that of the higher MW material, including limited absorption in biological systems. As a result, the assessment of the oligomers with a MW <1,000 were performed in a manner identical to the remaining components of the polymer.

Polymeric: Yes

Oligomers: This substance is a brominated epoxy polymer end-capped with tribromophenol. Tribromophenol end-capped epoxy polymer typically consists of oligomers with an average MW of 15,000 with 0% MW <1,000. The MW of the simplest oligomer comprised of each monomer is 970.

Metabolites, Degradates and Transformation Products: None

Analog: No analog

Endpoint(s) using analog values: Not applicable

Analog Structure: Not applicable

Structural Alerts: None identified

Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).

Hazard and Risk Assessments: A hazard characterization was completed for Brominated epoxy resin end-capped with tribromophenol in 2010 (EPA, 2010).

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	180–220 (Measured)	ICL Industrial Products, 2009	The melting points reported cover a broad range and are anticipated to be formulation specific liquid-glass transition temperatures for the commercial product F-3100.
	105–120 (Measured)	NICNAS, 2006	The melting points reported cover a broad range and are anticipated to be formulation specific liquid-glass transition temperatures for the commercial product F-3020, the brominated epoxy resin end-capped with tribromophenol with low MW oligomers that is expected to behave similarly to the high MW polymer.
Boiling Point (°C)	>300 (Estimated)	Professional judgment	Cutoff value used for large, high MW non-ionic polymers.
	Decomposition temperature: 340 (Measured)	ICL Industrial Products, 2009	The melting points reported cover a broad range and are anticipated to be formulation specific liquid-glass transition temperatures for the commercial product F-3100.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
Log K _{ow}			No data located; polymers with a MW >1,000 are outside the domain of the available estimation methods.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Explosivity		Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Pyrolysis				No data located.
pH		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
HUMAN HEALTH EFFECTS				
Toxicokinetics		There is no absorption expected for any route of exposure. This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore is not expected to be readily absorbed, distributed or metabolized in the body.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption is expected for all routes of exposure (Estimated)	Professional judgment	Estimated based on limited bioavailability and professional judgment.
Acute Mammalian Toxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for acute mammalian toxicity.		
	Oral	Rat Oral LD ₅₀ >2,000 mg/kg (Acute Oral Toxicity-Limit Test).	NICNAS, 2006	Reported in a secondary source. Conducted according to Organisation of Economic Cooperation and Development (OECD) TG 401 guideline study for the commercial product F-3020, the brominated epoxy resin end-capped with tribromophenol with low MW oligomers that is expected to behave similarly to the high MW polymer.
	Dermal			No data located.

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Carcinogenicity		LOW: This polymer is large, with a MW >1,000. It is expected to have few to no residual monomers, crosslinking, swellability, dispersability, reactive functional groups, potential for inhalation nor hindered amine groups and therefore has low potential for carcinogenicity.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large, high MW polymers.
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for genotoxicity. Bacterial reverse mutation test is negative for gene mutations.		
	Gene Mutation <i>in vitro</i>	Negative for gene mutations in <i>Salmonella typhimurium</i> strains TA1535, TA1537, TA1538, TA100, TA98 with and without exogenous metabolic activation	NICNAS, 2006	Reported in secondary sources. Guideline study according to OECD TG 471 for the commercial product F-3020, the brominated epoxy resin end-capped with tribromophenol with low MW oligomers that is expected to behave similarly to the high MW polymer.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>			No data located.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for reproductive effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large, high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for developmental effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large, high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for neurotoxicity.		
	Neurotoxicity Screening Battery (Adult)			No data located.
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW _n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations. No experimental data located.		

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		This polymer MW _n is >10,000; potential for irreversible lung damage as a result of lung overloading (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large, high MW polymers.
Skin Sensitization		LOW: No evidence of reactions indicative of skin sensitization to brominated epoxy resin end-capped with tribromophenol in a study of guinea pigs.		
	Skin Sensitization	No evidence of reactions indicative of skin sensitization, guinea pig skin sensitization – Magnusson & Kligman maximization test.	NICNAS, 2006	Reported in a secondary source. Conducted according to OECD TG 406 guideline study for the commercial product F-3020, the brominated epoxy resin end-capped with tribromophenol with low MW oligomers that is expected to behave similarly to the high MW polymer.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Brominated epoxy resin end-capped with tribromophenol is a mild eye irritant in rabbits; irritation begins to clear within 24 hours and is completely cleared within 48 hours.		
	Eye Irritation	Minimally irritating, rabbit; clearing within 24 hours and complete clearing within 48 hours; acute eye irritation/corrosion study.	NICNAS, 2006	Reported in a secondary source. Conducted according to OECD TG 405 guideline study for the commercial product F-3020, the brominated epoxy resin end-capped with tribromophenol with low MW oligomers that is expected to behave similarly to the high MW polymer.

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Dermal Irritation		VERY LOW: Brominated epoxy resin end-capped with tribromophenol is not irritating to the skin of rabbits.		
	Dermal Irritation	Non-irritating to the skin of rabbits, acute dermal irritation/corrosion study.	NICNAS, 2006	Reported in a secondary source. Conducted according to OECD TG 404 guideline study for the commercial product F-3020, the brominated epoxy resin end-capped with tribromophenol with low MW oligomers that is expected to behave similarly to the high MW polymer.
Endocrine Activity		This polymer is large, with a MW >1,000. It is not expected to have endocrine activity due to its poor bioavailability and inability to be readily metabolized in the body.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large, high MW polymers.
Immunotoxicity		This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for immunotoxicity.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large, high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to display no effects at saturation (NES). These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for acute aquatic toxicity for those materials that display NES.		
Fish LC₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid LC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae EC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity	LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to display NES. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for chronic aquatic toxicity for those materials that display NES.		
Fish ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
ENVIRONMENTAL FATE			
Transport	The estimated negligible water solubility and estimated negligible vapor pressure indicate that this polymer is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of <10⁻⁸ atm-m³/mole indicates that it is not expected to volatilize from water to the atmosphere. The estimated K_{oc} of >30,000 indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to adsorb strongly to soil and sediment.
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: This polymer is large, with a MW >1,000. It is expected to have negligible water solubility and poor bioavailability to microorganisms indicating that neither biodegradation nor hydrolysis are expected to be important removal processes in the environment. Although debromination by photodegradation of polybrominated benzenes has been observed, this process is not anticipated to lead to ultimate removal of the material. As a result, a half-life for this high MW polymer of >180 days leads to a potential for very high persistence.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW polymers.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.

Brominated Epoxy Resin End-Capped with Tribromophenol CASRN 135229-48-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reactivity	Photolysis	Not a significant fate process (Estimated)	Professional judgment	Bromine substituents are susceptible to photolysis however; this is expected to be a relatively slow process for brominated epoxy resin end-capped with tribromophenol and is not anticipated to lead to ultimate removal of the material.
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.
Environmental Half-Life		>180 days (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. Other degradative processes under environmental conditions are not anticipated to be facile.
Bioaccumulation		LOW: Due to the large size and water insolubility of this high MW polymer, it is of low potential for bioconcentration or bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW, insoluble polymers according to polymer assessment literature.
	BAF			No data located.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

Boethling, Robert S. and Nabholz, J. Vincent “Environmental Assessment of Polymers under the U.S. Toxic Substances Control Act”, pp. 187-234, in Ecological Assessment of Polymers Strategies for Product Stewardship and Regulatory Programs, Hamilton, John D. and Sutcliffe, Roger (eds.), (1997) Van Nostrand Reinhold.

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EPA (U.S. Environmental Protection Agency). Office of Pollution Prevention and Toxics. *Screening-Level Hazard Characterization Document for Phosphoryl Chloride, Polymer with Resorcinol Phenyl Ester (CASRN 125997-21-9)*. U.S. Environmental Protection Agency: Washington D.C. **2010**.
http://www.epa.gov/chemrtk/hpvis/hazchar/125997219_Phosphoryl%20chloride,%20polymer%20with%20resorcinol%20phenyl%20ester_%20June%202010.pdf (accessed April 5, 2012).

ESIS (European chemical Substances Information System) Classification, labeling and packaging of dangerous substances annex VI to regulation (EC) No 1272/2008 [Online] available at: <http://ecb.jrc.ec.europa.eu/esis/index.php?PGM=cla> as of May 10, **2011**.

ICL Industrial Products. Material Safety Data Sheet (MSDS) for *F-3100*. www.icl-ip.com. **2009**.

NICNAS (National Industrial Chemicals Notification and Assessment Scheme). *Phenol, 4,4'-(1-methylethylidene)bis[2,6-dibromo-, polymer with (chloromethyl)oxirane and 2,4,6-tribromophenol (F-3020)*. File No. LTD/1261. **2006**.

Brominated Polyacrylate

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

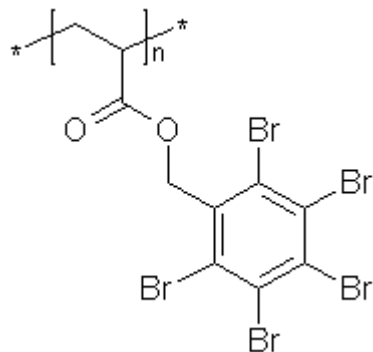
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Brominated Polyacrylate	59447-57-3	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i> ^d	<i>L</i>		<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>VH</i>	<i>L</i>

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Brominated Polyacrylate



CASRN: 59447-57-3

MW: 80,000 (Measured); 0% <1,000

MF: (C₁₀H₅Br₅O₂)_n

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: This polymer with MW >1,000 and no low MW components is not amenable to SMILES notation.

Synonyms: 2-Propenoic acid, (2,3,4,5,6-pentabromophenyl)methyl ester, homopolymer; 2-Propenoic acid, (pentabromophenyl)methyl ester, homopolymer; Ameribrom FR 1025; FR 1025; FR 1025P; PBB-PA; Pentabromo-benzyl-acrylate, polymer; (Poly)pentabromobenzyl acrylate; Poly(2,3,4,5,6-pentabromobenzyl acrylate); Polymer of 2,3,4,5,6-pentabromobenzyl acrylate; Pentabromobenzyl acrylate homopolymer; Ameribrom FR 1025; FR 1025; FR 1025P; PBB-PA

Chemical Considerations: This alternative is a high MW polymer. The high MW (MW >1,000) oligomers were assessed together using information contained in the literature concerning polymer assessment and professional judgment (Boethling et al., 1997).

Polymeric: Yes

Oligomers: The formula for this polymer is (C₁₀H₅Br₅O₂)_n and the average MW is approximately 80,000 daltons (NICNAS, 2001) with oligomers below 500 or 1,000 not expected.

Metabolites, Degradates and Transformation Products: None

Analog: No analog

Analog Structure: Not applicable

Endpoint(s) using analog values: Not applicable

Structural Alerts: None identified

Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community & IUCLID (Pakalin et al., 2007).

Hazard and Risk Assessments: None identified

Brominated Polyacrylate CASRN 59447-57-3			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	180 (glass transition temperature) (Measured)	Sigma-Aldrich, 2011	The melting points reported cover a broad range and are anticipated to be formulation specific liquid-glass transition temperatures.
	190-220 (glass transition temperature) (Measured)	NICNAS, 2001; Mack, 2004	
Boiling Point (°C)	>300 (Estimated)	Professional judgment	Cutoff value used for large, high MW solid.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW polymers.
	<0.075 (Measured)	NICNAS, 2001	Reported in a secondary source. Insufficient information provided to assess the quality of the data.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW polymers.
	3.5-3.8 (Measured)	NICNAS, 2001	Reported in a secondary source; value inconsistent with that expected for a highly halogenated polymer with a MW >10,000.
Log K_{ow}			No data located; polymers with a MW >1,000 are outside the domain of the available estimation methods.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH			No data located.
pK_a			No data located.

Brominated Polyacrylate CASRN 59447-57-3

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		Brominated polyacrylate has a MW >1,000 and limited water solubility. There is no absorption expected for any route of exposure for this compound; therefore it is not expected to be absorbed, distributed or metabolized in the body. The lack of absorption is expected to result in low hazard potential.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption is expected for all routes of exposure (Estimated by analogy)	Professional judgment	Estimated based on professional judgment.
Acute Mammalian Toxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for acute mammalian toxicity. No data located.		
Acute Lethality	Oral	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on polymer assessment literature.
	Dermal			
	Inhalation			
Carcinogenicity		LOW: This polymer is large, with a MW >1,000. It is expected to have few to no residual monomers. Additionally, crosslinking, swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected and therefore this chemical has a low potential for carcinogenicity. No data located.		
	OncoLogic Results	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Carcinogenicity (Rat and Mouse)			
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for genotoxicity. No data located.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Gene Mutation <i>in vivo</i>			
	Chromosomal Aberrations <i>in vitro</i>			
	Chromosomal Aberrations <i>in vivo</i>			
	DNA Damage and Repair			

Brominated Polyacrylate CASRN 59447-57-3

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Other (Mitotic Gene Conversion)			
Reproductive Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for reproductive effects. No data located.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for developmental effects. No data located.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for neurotoxicity. No data located.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.

Brominated Polyacrylate CASRN 59447-57-3

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW_n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations. No experimental data located.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
		This polymer MW _n is >10,000; potential for irreversible lung damage as a result of lung overloading (Estimated by analogy)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Skin Sensitization		LOW: Estimated not to have potential for skin sensitization based on expert judgment.		
	Skin Sensitization	Low potential for skin sensitization (Estimated)	Expert judgment	Estimated based on expert judgment.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Estimated not to have potential for eye irritation based on expert judgment.		
	Eye Irritation	Low potential for eye irritation (Estimated)	Expert judgment	Estimated based on expert judgment.
Dermal Irritation		LOW: Estimated not to have potential for dermal irritation based on expert judgment.		
	Dermal Irritation	Low potential for dermal irritation (Estimated)	Expert judgment	Estimated based on expert judgment.
Endocrine Activity		This polymer is large, with a MW >1,000. It is not expected to have endocrine activity due to its limited bioavailability and inability to be readily metabolized in the body.		
				No data located.
Immunotoxicity		This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for immunotoxicity. No data located.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		

Brominated Polyacrylate CASRN 59447-57-3

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Acute Toxicity	LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to display no effects at saturation (NES). These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard results in a Low hazard categorization for those materials that display NES.		
Fish LC₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid LC₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae EC₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity	LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to display NES. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard results in a low hazard categorization for those materials that display NES.		
Fish ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

Brominated Polyacrylate CASRN 59447-57-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that this polymer is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of $<10^{-8}$ atm-m ³ /mole indicates that it is not expected to volatilize from water to the atmosphere. The estimated K _{oc} of $>30,000$ indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m ³ /mole)	$<10^{-8}$ (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	$>30,000$ (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to adsorb strongly to soil and sediment.
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: This polymer is large, with a MW $>1,000$. It is expected to have negligible water solubility and limited bioavailability to microorganisms indicating that neither biodegradation nor hydrolysis are expected to be important removal processes in the environment. Although photodegradation of polybrominated benzenes has been observed, this process is not anticipated to lead to ultimate removal of the material. As a result, a half-life for this high MW polymer of >180 days leads to the potential for very high persistence.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation with Product Identification			No data located.

Brominated Polyacrylate CASRN 59447-57-3

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis		Professional judgment	Bromine substituents are susceptible to photolysis; however this is expected to be a relatively slow process for brominated polyacrylate and is not anticipated to lead to ultimate removal of the material.
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.
Environmental Half-Life		>180 days (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. Other degradative processes under environmental conditions are also not anticipated.
Bioaccumulation		LOW: Due to the large size and limited bioavailability of this polymer, it has low potential for bioconcentration or bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW, insoluble polymers.
	BAF			No data located.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		

Brominated Polyacrylate CASRN 59447-57-3

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Human Biomonitoring	This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

Boethling, Robert S. and Nabholz, J. Vincent “Environmental Assessment of Polymers under the U.S. Toxic Substances Control Act”, pp. 187-234, in Ecological Assessment of Polymers Strategies for Product Stewardship and Regulatory Programs, Hamilton, John D. and Sutcliffe, Roger (eds.), (1997) Van Nostrand Reinhold.

CDC (Centers for Disease Control and Prevention). *Fourth national report on human exposure to environmental chemicals, updated tables*. Department of Health and Human Services. **2011**. http://www.cdc.gov/exposurereport/pdf/Updated_Tables.pdf (accessed on May 10, 2011).

EPA (U.S. Environmental Protection Agency) Sustainable Futures. *Using NonCancer Screening within the SF Initiative*. U.S. Environmental Protection Agency: Washington D.C. **2010**. <http://www.epa.gov/opptintr/sf/pubs/noncan-screen.htm#systemic> (accessed February 09, 2011).

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NICNAS (National Industrial Chemicals Notification and Assessment Scheme). Priority Existing Chemical Assessment Report No. 20. Polybrominated Flame Retardants (PBFRs) [Online] June **2001**. http://www.nicnas.gov.au/publications/car/pec/pec20/pec_20_full_report_pdf.pdf

Pakalin, S.; Cole, T.; Steinkellner, J.; et al. Review on production processes of decabromodiphenyl ether (DECABDE) used in polymeric applications in electrical and electronic equipment, and assessment of the availability of potential alternatives to DECABDE. [Online] January 2007. http://ecb.jrc.ec.europa.eu/documents/Existing-Chemicals/Review_on_production_process_of_decaBDE.pdf (accessed on January 20, 2011).

Sigma-Aldrich. On-line Catalog **2011**. <http://www.sigmaaldrich.com/catalog/> (accessed on April 14, 2011).

Brominated Poly(phenylether)

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment. □ This alternative may contain impurities. These impurities have hazard designations that differ from the flame retardant alternative, Brominated poly(phenylether), as follows, based on experimental data: HIGH for human health, HIGH for aquatic toxicity, VERY HIGH for bioaccumulation, and VERY HIGH for persistence. ^T This chemical is subject to testing in an EPA consent order for this endpoint.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Brominated Poly(phenylether)	Confidential	L	L□	L	VL□	M□	L□	L□	L		L	VL	L	L□	VH ^T	H ^T □

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Brominated Poly(phenylether)

	CASRN: Confidential CASRN
	MW: >1,000
	MF: Confidential MF
	Physical Forms: Neat: Solid
	Use: Flame retardant
SMILES: Confidential SMILES notation; not amenable to the generation of a SMILES notation	
Synonyms: Emerald Innovation 1000™; Brominated PPE; Br PPE	
Chemical Considerations: This material was assessed using guidance from High Production Volume criteria, information contained in the literature concerning polymer assessment, and by analysis of confidential materials with similar structures, substituents, and MWs, in the absence of experimental values (EPA, 1999; Boethling et al., 1997). Impurities have been found in analogous substances and could potentially be present in this substance. A summary of the hazard designations for the impurities are provided in the hazard summary table. This chemical is subject to testing for persistence and bioaccumulation endpoints. Testing for the presence of impurities is also required under consent order.	
Polymeric: Not a polymer by EPA definition (EPA, 1997)	
Oligomers: Not applicable	
Metabolites, Degradates and Transformation Products: Photodegradation – potential for debromination (Professional judgment)	
Analog: None	Analog Structure: Not applicable
Endpoint(s) using analog values: Not applicable	
Structural Alerts: None identified	
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2012).	
Hazard and Risk Assessments: None identified	

Brominated Poly(phenylether)			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	186-307 (Measured) According to a modified capillary method/melting temperature device with liquid bath method and designed to be compatible with Organisation of Economic Cooperation and Development (OECD) Guideline 102	Submitted confidential study	Adequate, guideline study.
	270-329 (Measured) According to an OECD guideline study.	Submitted confidential study	Adequate, guideline study.
Boiling Point (°C)	>450 at 102.81 kPa (Measured) According to a differential scanning calorimetry procedure American Society for Testing and Materials (ASTM) E537-86, designed to be compatible with OECD Guideline 103	Submitted confidential study	Cutoff value obtained from guideline study.
Vapor Pressure (mm Hg)	$<9.8 \times 10^{-7}$ at 25°C (Measured) According to OECD Guideline 104	Submitted confidential study	Cutoff value obtained from guideline study.
Water Solubility (mg/L)	$<6.63 \times 10^{-5}$ at 20°C (Measured) Determined to be less than the limit of quantitation (LOQ) according to the column elution method, Test Guidelines, OPPTS 830.7840	Submitted confidential study	Cutoff value obtained from a guideline study.
	$\leq 7.96 \times 10^{-2}$ at 20°C (Measured) According to the column elution method, designed to be compatible with OECD Guideline 105	Submitted confidential study	Cutoff value obtained from a study equivalent to a guideline study.
Log K_{ow}	>9.4 (Measured) According to high performance liquid chromatography (HPLC) Method designed to be compatible with for OECD Guideline Method 117	Submitted confidential study	Cutoff value obtained from guideline study.

Brominated Poly(phenylether)			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Flammability (Flash Point)	Not highly flammable (Measured) According to Method A10 Flammability (Solids) of Commission Regulation (EC) No 440/2008	Submitted confidential study	Adequate, guideline studies.
	No relative self-ignition temperature below its melting temperature (Measured) According to a study compatible with method A16 Relative Self-Ignition Temperature for Solids of Commission Regulation (EC) No 440/2008	Submitted confidential study	
	>10 J is the lowest spark energy capable of igniting a dispersed dust of this mixture according to ASTM E 2019 Standard Test Method for the Minimum Ignition Energy of a Dust Cloud in Air and IEC 61241-2-3 Part 2 Section 3 (Measured)	Submitted confidential study	
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	This material does not contain any function groups that are anticipated to ionize in solution.
pK _a	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		Poor absorption is expected. Even though this substance is large and poorly soluble in water, its structure and potential for debromination suggest it could be bioavailable. No data located.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Poor absorption is expected for all routes of exposure based on physical/chemical properties (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.
Acute Mammalian Toxicity		LOW: Available experimental data indicate a Low hazard designation. Based on oral and dermal LD ₅₀ >2,000 mg/kg. There were no acute toxicity data located for the inhalation route.		
Acute Lethality	Oral	Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.
		Rat, oral LD ₅₀ >2,000 mg/kg	Confidential study	Reported in a submitted confidential study; study conducted according to OECD 420.
	Dermal	Rat, oral LD ₅₀ >2,000 mg/kg	Confidential study	Reported in a submitted confidential study; study conducted according to OECD 402.
	Inhalation			No data located.
Carcinogenicity		LOW: This material has a MW >1,000 and limited water solubility. It is expected to have limited bioavailability and few to no low MW components. Additionally, no crosslinking, swellability, dispersability, reactive functional groups, potential for inhalation, or hindered amine groups are expected and therefore this chemical has a low potential for carcinogenicity. No experimental data located.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.
	Combined Chronic Toxicity/ Carcinogenicity			

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Genotoxicity		LOW: This material did not cause gene mutations in bacteria or in L5178Y TK +/- mouse cells, and did not cause chromosomal aberrations in human lymphocyte cells <i>in vitro</i>.		
	Gene Mutation <i>in vitro</i>	Negative, Ames assay of <i>Salmonella typhimurium</i> strains TA98, TA100, TA1535, TA1537 and <i>Escherichia coli</i> WP2 <i>uvrA</i> both with and without metabolic activation.	Submitted confidential study	Study conducted according to OECD test guideline 471. Test substance purity: 100%.
		Negative for mutagenicity in a L5178Y TK +/- mouse lymphoma assay with or without metabolic activation	Confidential study	Study details reported in a submitted confidential study; conducted according to OECD 476; test substance purity: 100%.
	Gene Mutation <i>in vivo</i>	Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.
	Chromosomal Aberrations <i>in vitro</i>	Negative for chromosomal aberrations in human lymphocytes both with and without metabolic activation.	Submitted confidential study	Study conducted according to OECD test guideline 473. Test substance purity: 100%.
	Chromosomal Aberrations <i>in vivo</i>	Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.
	DNA Damage and Repair			No data located.
	Other			No data located.
Reproductive Effects		VERY LOW: No reproductive effects were noted in a reproduction/developmental toxicity screening test in rats at doses up to 1,000 mg/kg-day.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Reproduction/developmental toxicity screening test in rats orally (gavage) exposed to 0, 100, 300, or 1,000 mg/kg-day for up to 8 weeks (2 week maturation phase, pairing, gestation and early lactation (females). Maternal toxicity: there were no effects on body weight or food and water consumption; No treatment-related effects on mating, conception rates or gestation lengths were reported NOAEL = 1,000 mg/kg-day (highest dose tested)	Confidential study	Study details reported in a submitted confidential study; conducted according to OECD 421.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects			No data located.
Developmental Effects		MODERATE: No developmental effects were noted in a reproduction/developmental toxicity screening test in rats at doses up to 1,000 mg/kg-day. Potential for developmental neurotoxicity by analogy to brominated diphenyl ethers cannot be ruled out therefore a moderate designation is applied conservatively.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected although similarity to brominated diphenyl ethers raises a structural alert associated with developmental neurotoxicity (Estimated)	Professional judgment	Professional judgment based on the analysis of substances with similar structures, substituents, and MW.
		Reproduction/developmental toxicity screening test in rats orally (gavage) exposed to 0, 100, 300, or 1,000 mg/kg-day for up to 8 weeks (2 week maturation phase, pairing, gestation and early	Confidential study	Study details reported in a submitted confidential study; conducted according to OECD 421.

Brominated Poly(phenylether)			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	lactation (females); Maternal toxicity: there were no effects on body weight or food and water consumption; Developmental effects: There were no changes in litter size at birth and on post-partum days 1 and 4 compared to controls; offspring body weight gain and litter weights on post-partum days 1 and 4 were also comparable to controls; No clinical signs of toxicity or changes in organ weights were observed in offspring; in addition there were no relevant macroscopic or microscopic abnormalities observed. Maternal and Developmental: NOAEL = 1,000 mg/kg-day (highest dose tested) LOAEL >1,000 mg/kg-day		
Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
Prenatal Development			No data located.
Postnatal Development			No data located.
Neurotoxicity	LOW: Estimated based on physical chemical properties and limited experimental data. This material has a MW >1,000 and limited water solubility. It is expected to have limited bioavailability and therefore is of low potential for neurotoxicity. There were no treatment-related changes in behavioral parameters, functional performance tests or sensory reactivity in a 28-day repeated dose study in rats; this study was not designed as a comprehensive neurotoxicity study.		

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.
		28-day repeated dose oral (gavage) study in rats exposed to 0, 30, 300, or 1,000 mg/kg-day; There were no treatment-related changes in behavioral parameters, functional performance tests or sensory reactivity. NOAEL = 1,000 mg/kg-day (highest dose tested) LOAEL >1,000 mg/kg-day	Confidential study	Reported in a submitted confidential study; study conducted according to OECD 407.
Repeated Dose Effects		LOW: Available experimental data reported no effects in rats at a dose of 1,000 mg/kg-day (highest dose tested) following 7- or 28-day repeated dose studies.		
		Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.

Brominated Poly(phenylether)			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	28-day repeated dose oral (gavage) study in rats exposed to 0, 30, 300, or 1,000 mg/kg-day; No mortality or clinical signs reported; No changes in body weight, food consumption, water consumption, hematology, blood chemistry, urinalysis, organ weights or thyroid hormone levels were observed; necropsy and histopathology did not reveal any treatment related abnormalities; In addition, there were no treatment-related changes in behavioral parameters, functional performance tests or sensory reactivity. NOAEL = 1,000 mg/kg-day (highest dose tested) LOAEL >1,000 mg/kg-day	Confidential study	Reported in a submitted confidential study; study conducted according to OECD 407; test substance purity: 100%.
	7-day repeated dose oral (gavage) range-finding toxicity study in rats exposed to 0, 250, 500, or 1,000 mg/kg-day; No mortality or clinical signs of toxicity reported; no effects on body weight or food and water consumption were reported; No macroscopic abnormalities were reported. NOAEL = 1,000 mg/kg-day LOAEL >1,000 mg/kg-day	Confidential study	Reported in a submitted confidential study; test substance purity: 100%.

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Skin Sensitization		LOW: This test substance is not a skin sensitizer based on results of a local lymph node assay in mice.		
	Skin Sensitization	Low potential for skin sensitization (Estimated)	Expert judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.
		Not a skin sensitizer in a local lymph node assay in mice.	Confidential study	Study details reported in a submitted confidential study; conducted according to OECD 429; test substance purity: 100%.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: This material was a minimal eye irritant in rabbits.		
	Eye Irritation	Minimally irritating in rabbits; clearing within 24 hours.	Submitted confidential study	Study conducted according to OECD test guideline 405. Test substance purity: 100%.
Dermal Irritation		VERY LOW: This material was not a skin irritant in rabbits.		
	Dermal Irritation	No evidence of skin irritation in rabbits.	Submitted confidential study	Study conducted according to OECD test guideline 404; single 4-hour, semi-occluded application to intact skin. Test substance purity: 100%.
Endocrine Activity		No data located. This material has a MW >1,000 and limited water solubility. It is not expected to have endocrine activity due to its poor bioavailability and inability to readily metabolize in the body.		
		Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Immunotoxicity		This material has a MW >1,000 and limited water solubility. It is expected to have limited bioavailability and therefore is of low potential for immunotoxicity. No experimental data located.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment	Professional judgment based on the analysis of confidential materials with similar structures, substituents, and MW.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Experimental data in fish, daphnia, and algae indicate no effects at saturation (NES). In addition, non-ionic solids with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW components are estimated to display NES. These solids display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for hazard for those materials that display NES.		
Fish LC ₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
		<i>Oncorhynchus mykiss</i> (rainbow trout) 96-hour Lethal Loading Rate (LL ₅₀) >100 mg/L; No Observed Effect Loading rate = 100 mg/L (Experimental)	Submitted confidential study	Conducted according to OECD 203; test substance purity was described as “natural complex substance”; fish were exposed to water accommodated fraction (WAF) at a single nominal loading rate of 100 mg/L). The concentration in the WAF ranged from 0.184 to 0.0270 mg/L between zero and 96 hours of the test. Toxicity cannot be attributed to a single component of the mixture and is based on nominal loading rates; There were no adverse effects at the limit of water solubility; therefore, NES is predicted.

Brominated Poly(phenylether)			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid LC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
	<i>Daphnia magna</i> 48-hour Effective Loading Rate (EL ₅₀) >100 mg/L; No Observed Effect Loading rate = 100 mg/L (static test conditions) (Experimental)	Submitted confidential study	Conducted according to OECD 202; test substance purity was described as “natural complex substance”; <i>Daphnia</i> exposed to WAF at a single nominal loading rates of 100 mg/L). The concentration in the WAF ranged from 0.0436 mg/L to the limit of quantitation between zero and 48 hours of the test. Toxicity cannot be attributed to a single component of the mixture and are based on nominal loading rates; There were no adverse effects at the limit of water solubility; therefore, NES is predicted.
Green Algae EC ₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
	<i>Pseudokirchneriella subcapitata</i> 72-hour Effective Loading rate (EL ₅₀) >100 mg/L (growth rate); No Observed Effect Loading rate = 100 mg/L (Experimental)	Submitted confidential study	Conducted according to OECD 201; test substance purity: 100%; algae exposed to WAF at a single nominal loading rates of 100 mg/L). The concentration in the WAF ranged from less than the limit of quantitation to 0.19 mg/L between zero and 72 hours of the test. Toxicity cannot be attributed to a single component of the mixture and are based on nominal loading rates; There were no adverse effects at the limit of water solubility; therefore, NES is predicted.

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Chronic Aquatic Toxicity		LOW: Test data regarding chronic aquatic toxicity for fish and algae were not located on this substance therefore potential for hazard is uncertain. Test data for daphnids included water accommodated fractions with test substance below limit of quantitation suggesting NES due to poor solubility.		
Fish ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
		<i>Daphnia magna</i> 21- day; Semi-static test conditions 21-day EL ₅₀ (reproduction) >100 mg/L NOEC (reproduction) = 100 mg/L LOEC (reproduction) >100 mg/L 21-day EL ₅₀ (growth) >100 mg/L NOEC (growth) = 100 mg/L LOEC (growth) >100 mg/L (Experimental)	Submitted confidential study	Conducted according to OECD 211; test substance composition and/or purity not specified; <i>Daphnia</i> exposed to WAF at nominal loading rates of 1.0, 3.2, 10, 32, and 100 mg/L. The concentration in the WAF was below the limit of quantitation at on day 0, 2, 9, 12, 19 and 21 in both fresh and old media.
Green Algae ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that this substance is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of <10 ⁻⁸ atm-m ³ /mole indicates that it is not expected to volatilize from water to the atmosphere. The measured K _{oc} of >430,000 indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment	Cutoff value for nonvolatile compounds.

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated)	EPA, 2004; Professional judgment	Cutoff value for nonmobile compounds.
		K _{oc} >430,000 (Measured) According to an HPLC screening method, designed to be compatible to OECD Guideline 121	Submitted confidential study	Cutoff value obtained from guideline study.
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: This substance has a MW >1,000. It is expected to have negligible water solubility and poor bioavailability to microorganisms indicating that biodegradation is not expected to be an important removal processes in the environment. One experimental biodegradation test using activated sludge resulted in no degradation after 28 days. Estimated hydrolysis half-lives of >1 year indicate that this will not be an important environmental removal process. Although photodegradation of brominated aromatic compounds has been observed, this process is not anticipated to lead to ultimate removal of the material. As a result, a half-life for this high MW solid is expected to be >180 days. While test data from environmental fate studies were not located on this substance, EPA has predicted its behavior in the environment based upon physical-chemical properties and data on structurally similar chemicals. To enable a reasoned evaluation of the human health and environmental effects of the Premanufacture Notice (PMN) substance and potential degradation products, EPA requires the manufacturer to provide test data on this substance using the OPPTS 835.4400 test guideline on anaerobic metabolism in aquatic sediment 24 months from commencement of manufacture or prior to a confidential production volume, whichever comes later. EPA and the manufacturer are also negotiating additional requirements for toxicity and environmental fate testing.		

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Water	Aerobic Biodegradation	Not readily degradable (Measured) 0% degraded/biochemical oxygen demand after 28 days; activated sludge ready biodegradability test; Method Relating to New Chemical Substances - Biodegradability Test of Chemical Substances by Microorganisms Yakushokuhatsu 0331 No. 7, Heisei 23.03.29 c- Seikyoku No. 5, Kanpokiatsu No. 110331009	Submitted confidential study	Study performed according to a standardized method.
		Not readily degradable (Measured) 0% degraded/CO ₂ evolution after 28 days; Method designed to be compatible with OECD 301B	Submitted confidential study	Study performed according to a standardized method.
		Toxicity of the test material to a mixed population of activated sewage sludge microorganisms was determined: EC ₅₀ >1000 mg/L after 3-hours NOEC = 1000 mg/L after 3 hours (Measured) According to OECD 209, method C.11 of EC No. 440/2008 and US EPA Draft Ecological Effects Test Guidelines OPPTS 850.6800	Submitted confidential study	Supporting information provided in study performed according to a standardized method.
		Recalcitrant (Estimated)	Professional judgment	High MW solids are expected to be non-biodegradable due to their limited bioavailability.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law constant.

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law constant.
Soil	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	High MW solids are expected to be nonbiodegradable due to their limited bioavailability.
	Anaerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	High MW solids are expected to be resistant to removal under anoxic conditions biodegradable due to their limited bioavailability.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	Not a significant fate process (Estimated)	Professional judgment	This chemical is expected to exist in the particulate phase in the atmosphere.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Professional judgment	The bromine substituent is susceptible to photolysis however; this is expected to be a relatively slow process and is not anticipated to lead to ultimate removal of the material.
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.

Brominated Poly(phenylether)				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Environmental Half-Life		>180 days (Estimated)	Professional judgment	The substance has a MW greater than 1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to be readily removed by other degradative processes under environmental conditions because of limited water solubility and lack of reactive functional groups.
Bioaccumulation		HIGH: The bioaccumulation designation for this compound is based upon physical-chemical properties and by analogy to structurally similar chemicals. As test data regarding bioaccumulation were not located on this substance, the potential for bioconcentration or bioaccumulation is uncertain. To enable a reasoned evaluation of the human health and environmental effects of the PMN substance and potential degradation products, EPA requires the manufacturer to provide test data on this substance using the OECD 305 test guideline for bioaccumulation in fish with dietary exposure, 36 months from commencement of manufacture or prior to attaining a confidential production volume, whichever comes later. Although this substance is large and insoluble in water, its structure and potential for debromination suggest it could be bioavailable with potential to accumulate, therefore a high hazard designation is applied conservatively.		
	Fish BCF	<100 (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by aquatic organisms; therefore, bioconcentration is not expected.
	BAF	Potential for bioaccumulation using criteria for a conservative approach (Estimated)	Professional judgment	This compound is outside the MW domain of the corresponding EPI models. The potential for bioaccumulation is based on analogy to a structurally similar confidential analog.
	Metabolism in Fish			No data located.

Brominated Poly(phenylether)			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL MONITORING AND BIOMONITORING			
Environmental Monitoring	No data located.		
Ecological Biomonitoring	No data located.		
Human Biomonitoring	This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

CDC (Centers for Disease Control and Prevention). *Fourth national report on human exposure to environmental chemicals, updated tables*. Department of Health and Human Services. **2011**. http://www.cdc.gov/exposurereport/pdf/Updated_Tables.pdf (accessed on January 16, 2012).

ESIS (European chemical Substances Information System) Classification, labeling and packaging of dangerous substances annex VI to Regulation (EC) No 1272/2008 [Online] <http://esis.jrc.ec.europa.eu/index.php?PGM=cla> (accessed on January 16, 2012).

EPA. (1997). "Polymer Exemption Guidance Manual." Retrieved December 18, 2013, from <http://www.epa.gov/oppt/newchems/pubs/polyguid.pdf>.

EPA (U.S. Environmental Protection Agency). High Production Volume (HPV) Challenge. *Determining the Adequacy of Existing Data*. U.S. Environmental Protection Agency: Washington D.C. **1999**. <http://www.epa.gov/hpv/pubs/general/datadfin.htm>

EPA. 2004. The Pollution Prevention (P2) Framework, EPA-748-B-03-001. Office of Pollution Prevention and Toxics 7403M, U.S. Environmental Protection Agency, Washington, DC. 20460. October 2003 version updated in January 2004. Latest version available at <http://www.epa.gov/opptintr/newchems/pubs/sustainable/p2frame-june05a2.pdf>

Brominated Polystyrene

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

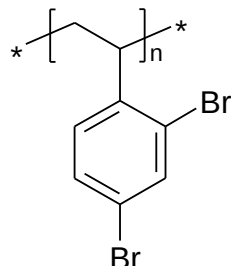
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Brominated Polystyrene	88497-56-7	L	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i> ^d	<i>L</i>		L	<i>L</i>	<i>L</i>	<i>L</i>	VH	<i>L</i>

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Brominated Polystyrene



CASRN: 88497-56-7

MW: 80,000 – 800,000 (Measured); 0%<1,000

MF: (C₈H_{8-m}Br_m)_n

Physical Forms:

Neat: Solid

Use: Flame retardant

Representative Structure

SMILES: This polymer with MW >1,000 and no low MW components is not amenable to SMILES notation.

Synonyms: Benzene, ethenyl-, homopolymer, brominated; Brominated ethenylbenzene homopolymer; Firemaster BP-411; Firemaster CP-44HF; FR-803P; Polystyrene, brominated; Pyro-Chek 68PB/BC; Saytex HP-775; Saytex HP-3010; Saytex HP-7010P; Saytex HP-7010G; Saytex HP-3010. Related trade name: PDBS 80 (CASRN 148993-99-1).

Chemical Considerations: This alternative is a high MW polymer. The number and locations of the bromines on the phenyl rings are unspecified and expected to be a variable mixture of mono, di, tri and tetra brominated materials. The ratio of m and n in the MF (C₈H_{8-m}Br_m)_n are product specific; although bromine content of 66-68% (m = 2.6-2.7) are typical (Mack, 2004). These high MW oligomers were assessed together using information contained in the literature concerning polymer assessment and professional judgment (Boethling et al., 1997). Closely related materials are indicated in the analog section.

Polymeric: Yes

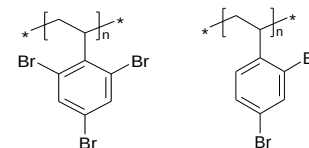
Oligomers: The general formula for this polymer is (C₈H_{8-m}Br_m)_n and the average MW is 80,000 to 800,000 daltons (NICNAS, 2001) with oligomers MW <1,000 not expected.

Metabolites, Degradates and Transformation Products: None

Analog: Tribrominated polystyrene (CASRN 57137-10-7); Benzene, ethenyl-, ar-bromo derivs., homopolymers (CASRN 148993-99-1)

Endpoint(s) using analog values: Decomposition

Analog Structures:



Representative Structure
CASRN 57137-10-7 CASRN 148993-99-1

Structural Alerts: None identified
Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community & IUCLID (Pakalin et al., 2007).
Hazard and Risk Assessments: None identified

Brominated Polystyrene CASRN 88497-56-7

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	195 (glass transition temperature) (Measured)	Ioffe and Kampf, 2002	The melting points reported cover a broad range and are anticipated to be formulation specific liquid-glass transition temperature.
	130-140 (glass transition temperature) (Measured)	Ioffe and Kampf, 2002	
Boiling Point (°C)	Decomposes (Estimated by analogy)	Professional judgment	Based on data from 148993-99-1.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW polymers.
Water Solubility (g/L)	<10 ⁻⁶ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
Log K_{ow}			No data located; polymers with a MW >1,000 are outside the domain of the available estimation methods.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK_a	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Brominated Polystyrene CASRN 88497-56-7

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		There is no absorption expected for any route of exposure. This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore is not expected to be readily absorbed, distributed or metabolized in the body.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption is expected for any route of exposure (Estimated)	Professional judgment	Estimated based on professional judgment.
Acute Mammalian Toxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore is of low potential for acute mammalian toxicity as confirmed by the available data.		
Acute Lethality	Oral	Rat Oral LD ₅₀ >15,380 mg/kg	Industrial Bio-Test Laboratories, 1977b	Guideline study.
	Dermal	Rabbit Dermal LD ₅₀ >3,038 mg/kg	Industrial Bio-Test Laboratories, 1977a	Guideline study.
	Inhalation	Rat Inhalation (dust) 4-hour LC ₅₀ >5.25 mg/L No gross tissue changes were observed (a mean aerodynamic diameter of 3.8 ± 1.97 microns)	Springborn Labs Inc., 1991	Guideline study.
Carcinogenicity		LOW: This polymer is large, with a MW >1,000. Based on professional judgment, It is expected to have few to no residual monomers. Additionally, crosslinking, swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected. Therefore there is low potential for carcinogenicity. No data located.		
	OncoLogic Results	Limited bioavailability expected; crosslinking, swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected. (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Carcinogenicity (Rat and Mouse)			
	Combined Chronic Toxicity/ Carcinogenicity			

Brominated Polystyrene CASRN 88497-56-7

Brominated Polystyrene CASRN 88497-56-7				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Genotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for genotoxicity. <i>In vitro</i> Ames test is negative for gene mutations.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
		Negative for gene mutations in <i>Salmonella typhimurium</i> strains TA1535, TA1537, TA1538, TA100, and TA98 with and without exogenous metabolic activation	Microbiological Associates, 1978	Guideline study.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>			No data located.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for reproductive effects. No data located.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for developmental effects. No data located.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.

Brominated Polystyrene CASRN 88497-56-7

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for neurotoxicity. No data located.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW_n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations. No experimental data located.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
		This polymer MW _n is >10,000; potential for irreversible lung damage as a result of lung overloading (Estimated by analogy)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Skin Sensitization		LOW: Estimated not to have potential for skin sensitization based on expert judgment. No data located.		
	Skin Sensitization	Not expected to be a skin sensitizer (Estimated)	Expert judgment	Estimated based on expert judgment.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Brominated polystyrene is a mild eye irritant in rabbits; irritation begins to clear within 24 hours and is completely cleared within 48 hours.		
	Eye Irritation	Minimally irritating, rabbit clearing within 24 hours	Industrial Bio-Test Laboratories, 1977b	Adequate, guideline study.
Dermal Irritation		LOW: Estimated not to have potential for dermal irritation. Available experimental data are inadequate to make a hazard designation for this endpoint.		
	Dermal Irritation	Not expected to be a skin irritant (Estimated)	Expert judgment	Estimated based on expert judgment.

Brominated Polystyrene CASRN 88497-56-7

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Moderately irritating, rabbit. Skin reactions characterized by pale red to red, well-defined erythema and moderate to severe edema that subsided by 7 days. Slight desquamation at test skin site at 14 days. (Test substance was administered as a fine powder in a slurry containing 1.0% aqueous methylcellulose)	Industrial Bio-Test Laboratories, 1977a	Result likely due to the presence of an impurity.
Endocrine Activity		This polymer is large, with a MW >1,000. It is not expected to have endocrine activity due to its poor bioavailability and inability to readily metabolize in the body. No data located.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Immunotoxicity		This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has a low potential for immunotoxicity. No data located.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers. These polymers display no effects at saturation (NES) because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Bioavailability is limited because this chemical cannot be absorbed through membranes due to large size.		
Fish LC₅₀		Fish (<i>Orizias latipes</i>) 48-hour TLm >500 mg/L (Experimental)	Nissan Ferro Organic Chem Inc, 1990	Inadequate; Organisation of Economic Cooperation and Development (OECD) guidelines recommend study duration of 96-hours for this endpoint. Units are not applicable to screening methodology.
		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

Brominated Polystyrene CASRN 88497-56-7

Brominated Polystyrene CASRN 88497-56-7				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Daphnid LC ₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae EC ₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity		LOW: Brominated polystyrene is comprised of non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Bioavailability is limited because this chemical cannot be absorbed through membranes due to large size.		
Fish ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that this polymer is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of <10 ⁻⁸ atm-m ³ /mole indicates that it is not expected to volatilize from water to the atmosphere. The estimated K _{oc} of >30,000 indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	Professional judgment Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to adsorb strongly to soil and sediment.

Brominated Polystyrene CASRN 88497-56-7

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: This polymer is large, with a MW >1,000. It is expected to have negligible water solubility and poor bioavailability to microorganisms indicating that neither biodegradation nor hydrolysis are expected to be important removal processes in the environment. Although photodegradation of brominated polystyrenes has been observed, this process is not anticipated to lead to ultimate removal of the material. As a result, a half-life for this high MW polymer of >180 days leads to the potential for very high persistence.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Photodegradation observed based on a decreased MW of brominated polystyrene (Measured)	Kaeriyama et al., 1972	The bromine substituent is susceptible to photolysis; however, this is expected to be a relatively slow process for brominated polystyrene and is not anticipated to lead to ultimate removal of the material.
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.

Brominated Polystyrene CASRN 88497-56-7

Brominated Polystyrene CASRN 88497-56-7				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Environmental Half-life		>180 days (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. Other degradative processes under environmental conditions are also not anticipated.
Bioaccumulation		LOW: Due to the large size and water insolubility of this high MW polymer, it is of low potential for bioconcentration or bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW, insoluble polymers.
	BAF			No data located.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

Boethling, Robert S. and Nabholz, J. Vincent "Environmental Assessment of Polymers under the U.S. Toxic Substances Control Act", pp. 187-234, in Ecological Assessment of Polymers Strategies for Product Stewardship and Regulatory Programs, Hamilton, John D. and Sutcliffe, Roger (eds.), (1997) Van Nostrand Reinhold.

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Industrial Bio-Test Laboratories Inc. (1977b). Report to Ferro Corporation, Acute toxicity studies with Jm-631. EPA Document No. 86-900000140, Fiche No. OTS0522211.

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Kaeriyama, K., Y. Shimura, et al. (1972). "Photodegradation of brominated polystyrene." J. Appl. Polym. Sci. **16**(11): 3035-3038.

Mack, A. G. (2004). Flame Retardants, Halogenated. Kirk-Othmer Encyclopedia of Chemical Technology., Wiley-Interscience.

Microbiological Associates (1978). Report to Ferro Corporation, Activity of JM-631 in the Salmonella/Microsomal assay for bacterial mutagenicity. EPA Document No. 86-90000014, Fiche No. OTS0522214.

Nissan Ferro Organic Chem Inc. (1990). Toxic level test and bioaccumulation test with brominated polystyrene (Sample \$S-346) in fish with test data. EPA Document No. 86-900000145, Fiche No. OTS0522216.

Pakalin, S., T. Cole, et al. (2007). Review on production processes of decabromodiphenyl ether (DECABDE) used in Polymeric applications in electrical and electronic equipment, and assessment of the availability of potential alternatives to DECABDE. European Commission Joint Research Centre.

Springborn Labs Inc. (1991). Acute inhalation toxicity study in rats with Pyro-Chek LM (amended final report). EPA Document No. 86-910000862, Fiche No. OTS0530450.

Decabromodiphenyl Ethane

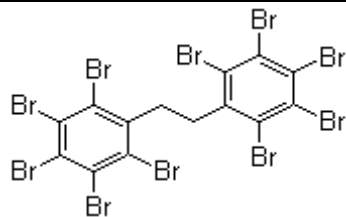
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment. [§] Based on analogy to experimental data for a structural similar compound.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Decabromodiphenyl Ethane	84852-53-9	L	M [§]	L	L	H [§]	L	L	L		VL	VL	L	L	VH	H

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Decabromodiphenyl Ethane



CASRN: 84852-53-9

MW: 971.2

MF: C₁₄H₄Br₁₀

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: c1(Br)c(Br)c(Br)c(Br)c(Br)c1CCc1c(Br)c(Br)c(Br)c(Br)c1Br

Synonyms: Benzene, 1,1'-(1,2-ethanediyl)bis[2,3,4,5,6-pentabromo-]; 1,1'-(1,2-Ethanediyl) bis[2,3,4,5,6-pentabromo-benzene]; Ethane 1,2-(bis-pentabromophenyl); EBP; Bis(pentabromophenyl) ethane; 1,1'-(ethane-1,2-diyl)bis[pentabromobenzene]; Decabromodiphenyl ethane; DBDP-Ethane; DBDPE; DBDiPhEt; DBDE; EBPE; DeBrPylE; Saytex 8010; Firemaster 2100

Chemical Considerations: This is a discrete organic chemical with a MW <1,000. EPI v 4.0 was used to estimate physical/chemical and environmental fate values due to an absence of experimental data. Measured values from experimental studies were incorporated into the estimations.

Polymeric: No

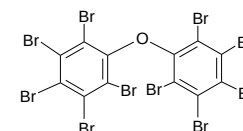
Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: Photodegradation – potential to form lower brominated congeners (Wang et al., 2010)

Analog: Decabromodiphenyl ether (decaBDE), confidential analogs

Endpoint(s) using analog values: Carcinogenicity; developmental toxicity; neurotoxicity; absorption, distribution, metabolism & excretion

Analog Structure:



DecaBDE
(1163-19-5)

Structural Alerts: Immunotoxicity, polyhalogenated aromatic hydrocarbons (EPA, 2011); test data are available to address this category.

Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community & IUCLID (Pakalin et al., 2007).

Hazard and Risk Assessments: An environmental risk evaluation report was completed by the UK government Environment Agency (Dungey et al., 2007).

Decabromodiphenyl Ethane CASRN 84852-53-9			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	350 (Measured)	Mack, 2004	Adequate.
Boiling Point (°C)	>350 (Estimated)	Professional judgment	Based on the reported experimental melting point value.
Vapor Pressure (mm Hg)	<7.5 x10 ⁻⁷ (Measured)	Hardy, 2004	Adequate.
Water Solubility (mg/L)	7.2x10 ⁻⁴ (Measured)	Hardy, 2004	Adequate.
Log K _{ow}	14 (Estimated)	EPI; EPA, 1999	Estimated value is greater than the cutoff value, >10, according to methodology based on HPV assessment guidance.
	3.55 According to column elution method OPPTS 830.7560. The concentration in the water phase was very close to the measured water solubility. It was noted that a higher stock solution concentration could have led to a higher K _{OW} value using this technique. (Measured)	Pakalin et al., 2007 and Dungey et al., 2007	The value was reported in a secondary source and was obtained using a guideline study, however, it is considered unreliable based on comparison to other substances that contain multiple bromine atoms.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Decabromodiphenyl Ethane CASRN 84852-53-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		Decabromodiphenyl ethane, as a neat material, is estimated to not be absorbed through the skin and to have poor skin absorption when in solution. Decabromodiphenyl ethane is expected to have poor absorption via the lungs and gastrointestinal (GI) tract. Decabromodiphenyl ethane is poorly absorbed in the GI tract following oral exposure and is mainly excreted in the feces. If absorption does occur, decabromodiphenyl ethane is distributed to the serum, liver, kidney, and adipose tissues and undergoes biotransformation to form metabolites.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Not absorbed through the skin as the neat material; poor absorption through skin if in solution; poor absorption from the lung and GI tract. (Estimated by analogy)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
		In an acute (single dose) oral study in rats, decabromodiphenyl ethane was poorly absorbed (if at all) in the GI tract and was excreted in the feces. There were no detectable levels of decabromodiphenyl ethane in bile, blood or urine. This finding is consistent with the poor solubility and the MW of decabromodiphenyl ethane.	Hardy, 2004	Guideline study (performed according to good laboratory practice (GLP)); reported in a secondary source; test substance: Saytex 8010.
		Rats, single oral (gavage) dose of 100 mg/kg-day of unlabeled and ¹⁴ C-labeled decabromodiphenyl ethane; tissues, bile and feces and urine were assayed for radiochemical content. In one group of rats that were euthanized 168 hours post dosing, 89% of radioactive content was recovered in the feces with none in urine; radioactivity in tissues were generally below the limit of detection with <0.2% of the dose found	Black, 2012	Unpublished study; the study suggests decabromodiphenyl ethane is poorly absorbed by the oral route.

Decabromodiphenyl Ethane CASRN 84852-53-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		in tissues. In another group of rats assayed 8 – 24 hours post-dosing by bile duct annulation, no bile samples had increased levels of radioactivity compared to controls. A group of jugular catheterized rats assayed at 0.25, 0.5, 1, 2, 6, 12, 24, 48, and 72 hours found that levels of radioactive content in blood and plasma were below the limit of detection at all time points; tissues from rats sacrificed at 2, 24, and 72 hours post exposure found the majority of radioactivity in the GI tract through 24 hours with no radioactivity found by 72 hours post exposure; it was presumed to have been excreted in the feces.		
		Rats, 90-day oral exposure; decabromodiphenyl ethane was found to be distributed to all tissues examined (serum, liver, kidney, and adipose); biotransformation occurred in rats, though debromination to lower brominated bromodiphenyl ethanes was not the primary metabolic pathway; proposed metabolites were identified as MeSO₂-nona-BDPE and EtSO₂-nona BDPE	Wang et al., 2010	The study suggests decabromodiphenyl ethane is absorbed by the oral route and biotransformation occurred.

Decabromodiphenyl Ethane CASRN 84852-53-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Acute Mammalian Toxicity		LOW: Based on a rat oral LD₅₀ of >5,000 mg/kg and a rabbit dermal LD₅₀ of >2,000 mg/kg. No acute inhalation hazard data located.		
Acute Lethality	Oral	Rat oral LD ₅₀ >5,000 mg/kg	Hardy et al., 2002; Hardy, 2004	Guideline study; test substance: Saytex 8010.
	Dermal	Rabbit dermal LD ₅₀ >2,000 mg/kg	Hardy et al., 2002; Hardy, 2004	Guideline study, reported in a secondary source; test substance: Saytex 8010.
	Inhalation			No data located.
Carcinogenicity		MODERATE: Potential for carcinogenicity based on analogy to decaBDE and professional judgment. No experimental carcinogenicity data for exposure to decabromodiphenyl ethane was located.		
	OncoLogic Results			Structure could not be evaluated by OncoLogic.
	Carcinogenicity (Rat and Mouse)	Potential for carcinogenicity; increased incidence of neoplastic nodules of the liver in rats; equivocal evidence of increased incidences of hepatocellular adenomas or carcinomas and thyroid gland follicular cell adenomas or carcinomas in male mice. (Estimated by analogy)	Professional judgment	Estimated based on the high potential for bioaccumulation and by analogy to decaBDE which resulted in potential carcinogenic effects following chronic exposure in a National Toxicology Program study.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.

Decabromodiphenyl Ethane CASRN 84852-53-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Genotoxicity		LOW: Based on negative experimental results for gene mutations in <i>Salmonella</i> and chromosomal aberrations in Chinese hamster ovary (CHO) cells.		
	Gene Mutation <i>in vitro</i>	Negative for gene mutations in <i>Salmonella typhimurium</i> strains TA98, TA100, TA1535, TA1537 and <i>Escherichia coli</i> WP2 uvrA with and without exogenous metabolic activation.	Hardy et al., 2002; Hardy, 2004	Guideline study (according to Japanese Ministry of International Trade and Industry (MITI) and GLP guidelines), reported in a secondary source; test substance: Saytex 8010.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative for chromosomal aberrations in CHO cells with and without metabolic activation.	Hardy et al., 2002; Hardy, 2004	Guideline study (according to MITI and GLP guidelines), reported in a secondary source; test substance: Saytex 8010.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: The located data suggest no reproductive effects based on a NOEL for maternal and fetal toxicity of $\geq 1,250$ mg/kg/day in rats and rabbits. However, there is uncertainty in this hazard designation because the exposure was of subchronic (gestational) duration and the studies were not experimentally designed as a reproduction toxicity screen or combined repeated dose/reproduction/developmental toxicity screen.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.

Decabromodiphenyl Ethane CASRN 84852-53-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Reproduction and Fertility Effects	There was no evidence of treatment-related adverse effects on the reproductive system in two developmental toxicity studies in rats and rabbits. NOEL (maternal and fetal) $\geq$1,250 mg/kg/day (highest dose tested) LOEL: not established	Hardy, 2004, Hardy et al., 2010	Guideline study (according to US Toxic Substances Control Act (TSCA) Guidelines and GLP) reported in a secondary source; test substance: Saytex 8010.
Developmental Effects		HIGH: Estimated to be High for developmental neurotoxicity based on analogy to decaBDE. There were no maternal or fetal toxicity effects in rats or rabbits exposed during gestation to doses up to 1,250 mg/kg/day decabromodiphenyl ethane. Some rodent developmental neurotoxicity studies of the analog decaBDE indicate adverse effects for the neurodevelopmental endpoint. There were no developmental neurotoxicity studies located for decabromodiphenyl ethane. Due to the analogous properties of decaBDE and decabromodiphenyl ethane, neurodevelopmental toxicity is predicted.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development	In two developmental oral gavage studies in mated female rats (gestation days (GD) 6-15) and rabbits (GD 6-18), there were no treatment-related fetal malformations or developmental variations. No maternal toxicity was evident. NOEL (maternal and fetal) $\geq$1,250 mg/kg/day (highest dose tested) LOEL: Not established	Hardy et al., 2002; Hardy, 2004; Hardy et al., 2010	Guideline study (according to US TSCA Guidelines and GLP) reported in a secondary source; test substance: Saytex 8010.

Decabromodiphenyl Ethane CASRN 84852-53-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Postnatal Development/Developmental Neurotoxicity	Evaluation of locomotor activity in C57BL6/J mice. NOAEL: not established LOAEL: 6 mg/kg-day (based on decreased T4 levels in male mice and effects on locomotor) (Estimated by analogy)	EPA, 2008; Washington DOE, 2008; Professional judgment	Estimated based on analogy to decaBDE; study details reported in a secondary source.
		Single dose gavage in male Sprague Dawley rats; NOAEL: Not established LOAEL: 6.7 mg/kg (Dose-related disruption in habituation [changes in locomotion, rearing, total activity] at both doses). (Estimated by analogy)	EPA, 2008; Professional judgment	Estimated based on analogy to decaBDE; each dose administered a single time; not a guideline study. Study details reported in a secondary source.
		NMRI male mice gavaged with decaBDE (99% pure) at 0, 2.22, or 20.1 mg/kg on PNDs3-19 or 0, 1.34, 13.4 or 20.1 mg/kg on PND10. Dose-related disruption in habituation (changes in locomotion, rearing, total activity) at 2, 4, and 6 months following exposure to 20.1 mg/kg on PND3. NOAEL: 2.22 mg/kg LOAEL: 20.1 mg/kg (Estimated by analogy)	European Chemicals Bureau 2002; EPA, 2008; Professional judgment	Estimated based on analogy to decaBDE; each dose administered a single time; not a guideline study. Study details reported in a secondary source.

Decabromodiphenyl Ethane CASRN 84852-53-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Neurotoxicity		LOW: There were no adult neurotoxicity studies of decabromodiphenyl ethane located. Developmental neurotoxicity is associated with the analog decaBDE, but does not directly trigger a hazard potential for adult neurotoxicity. There is no reported evidence to support a potential for hazard for adult neurotoxicity for this compound or analogous highly brominated compounds.		
	Neurotoxicity Screening Battery (Adult)	Low potential for neurological effects. (Estimated)	Professional judgment	Estimated based on the absence of structural alerts that have been [experimentally] associated with the adult neurotoxicity endpoint.
Repeated Dose Effects		LOW: Based on a NOAEL and LOAEL of $\geq 1,000$ mg/kg/day in 28 and 90-day oral rat studies, respectively. Experimental data for decabromodiphenyl ethane reported increased liver weights associated with minimal and transient hepatocellular vacuolization following a 90-day oral exposure. The increase in liver weights was associated with minimal to slight hepatocellular vacuolation, which had no long-term effect and was resolved after a 28-day recovery period at the highest doses tested (1,000 mg/kg/day). A LOAEL was not established in the 28-day study, as the highest doses tested did not produce adverse effects.		
		In a 28-day oral gavage study in rats, there was no mortality or clinical signs of toxicity, and no treatment-related statistically significant effects for changes in body weight, food consumption, body weight gain, hematology, serum chemistry, urinalysis, gross necropsy, relative and absolute organ weight, or histopathology. NOAEL >1,250 mg/kg/day (highest dose tested) LOAEL: not established	Hardy, 2004	Guideline study (according to US TSCA Guidelines and GLP), reported in a secondary source Organisation for Economic Cooperation and Development (OECD) 407; test substance: Saytex 8010.

Decabromodiphenyl Ethane CASRN 84852-53-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	In a 90-day oral gavage study in rats, there was no mortality, clinical or systemic signs of toxicity or ocular lesions; no changes in urine or serum chemistry, hematology, body weight, body weight gain or food consumption. Mean liver weights increased in males at the highest dose tested (but not at lower doses). Increased liver weight was associated with minimal to slight hepatocellular vacuolation and minimal to slight centrilobular hepatocytomegaly; liver changes returned to normal after a 28-day recovery period; no changes in female rat livers. There were no immunotoxicity effects, noted in a 90-day oral gavage study in rats. NOAEL $\geq$ 320 mg/kg/day LOAEL = 1,000 mg/kg/day (highest dose tested)	Hardy et al., 2002; Hardy, 2004	Guideline study (according to US TSCA Guidelines and GLP), reported in a secondary source; OECD 408; test substance: Saytex 8010.
	In a 90-day oral study in rats, there were no significant changes in body weight, or absolute and relative liver and kidney weights; hepatotoxicity indicated by changes in serum chemistry including increased TBA levels, decreased Cr, AST, and ALP activities; increased serum T3 thyroid hormone levels; increased CYP3A2 mRNA expression. LOAEL = 100 mg/kg/day (only dose tested)	Wang et al., 2010	Only one dose tested; a NOAEL was not established; no histopathological assessments were made on the liver; data are insufficient to determine a hazard designation for this endpoint.

Decabromodiphenyl Ethane CASRN 84852-53-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Skin Sensitization		LOW: Experimental data for decabromodiphenyl ethane were negative for skin sensitization in the guinea pig.		
	Skin Sensitization	Negative for skin sensitization, guinea pigs	Hardy et al., 2002; Hardy, 2004	Guideline study, reported in a secondary source; test substance: Saytex 8010.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		VERY LOW: Decabromodiphenyl ethane is not an eye irritant in rabbits.		
	Eye Irritation	Non-irritant, rabbit	Hardy et al., 2002; Hardy, 2004	Guideline study, reported in a secondary source; test substance: Saytex 8010.
Dermal Irritation		VERY LOW: Decabromodiphenyl ethane is not a skin irritant in rabbits.		
	Dermal Irritation	Non-irritant, rabbit	Hardy et al., 2002; Hardy, 2004	Guideline study, reported in a secondary source; test substance: Saytex 8010.
Endocrine Activity		There were limited data located for this endpoint.		
		90-day oral study in rats; increased serum T3 thyroid hormone levels; no effects on thyroxine levels	Wang et al., 2010	Only one dose tested; a NOAEL was not established, so it is uncertain where effects would occur; did not evaluate thyroid weight, or histopathology.
Immunotoxicity		There were no immunotoxicity effects noted in a 90-day oral gavage study in rats.		
	Immune System Effects	There were no immunotoxicity effects, noted in a 90-day oral gavage study in rats.	Hardy et al., 2002; Hardy, 2004	Guideline study (according to US TSCA Guidelines and GLP), reported in a secondary source; OECD 408; test substance: Saytex 8010.

Decabromodiphenyl Ethane CASRN 84852-53-9			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ECOTOXICITY			
ECOSAR Class			
Acute Toxicity	LOW: Experimental values for daphnia and fish, and ECOSAR estimations for green algae and saltwater invertebrate suggest that decabromodiphenyl ethane exhibits no effects at saturation (NES) and is not acutely toxic to fish, daphnia or green algae		
Fish LC₅₀	Rainbow trout (<i>Oncorhynchus mykiss</i>) 96-hour LLR ₅₀ >110 mg/L (static, nominal) (Experimental)	Hardy et al., 2012	The reported value was determined using a water accommodated fraction (WAF). According to OECD guidelines, WAFs should only be used to determine toxicity of multi-component substances. As a result, the reported value is greater than this material's water solubility.
	Fish 96-hour LC ₅₀ = 4.29x10 ⁻⁸ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 14 for this chemical exceeds the structure activity relationship (SAR) limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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Daphnid LC ₅₀	Daphnia (<i>Daphnia magna</i>) 48-hour LLR ₅₀ >110 mg/L (static, nominal) (Experimental)	Hardy et al., 2012	The reported value was determined using a WAF. According to OECD guidelines, WAFs should only be used to determine toxicity of multi-component substances. As a result, the reported value is greater than this material's water solubility.
	Daphnia (<i>Daphnia magna</i>) 48-hour EC ₅₀ = 19 µg/L (0.019 mg/L, nominal) (Experimental)	Nakari and Huhtala, 2010	Although in a guideline study (ISO 6341, 1996), the reported value is greater than the substance's water solubility (0.72 µg/L).
	Daphnia 48-hour LC ₅₀ = 1.35x10 ⁻⁷ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 14 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Saltwater Invertebrate LC ₅₀	Mysid Shrimp 96-hour LC ₅₀ = 28 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 14 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
			narcosis.
Green Algae EC ₅₀	Green Algae (<i>Pseudokirchneriella subcapitata</i>) 96-hour EL ₅₀ and NOAEL >110 mg/L (static, nominal) (Experimental)	Hardy et al., 2012	The reported value was determined using a WAF. According to OECD guidelines, WAFs should only be used to determine toxicity of multi-component substances. As a result, the reported value is greater than this material's water solubility.
	Green Algae 96-hour EC ₅₀ = 1.01x10 ⁻⁵ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 14 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Chronic Aquatic Toxicity	LOW: Estimated data suggest NES for chronic aquatic toxicity endpoints.		
Fish ChV	Zebra fish (<i>Danio rerio</i>) static-renewal (48-hr renewal intervals) egg-larvae test: LOEC = 12.5 µg/L (0.0125 mg/L, nominal) based on mortality of eggs and hatched larvae; NOEC <12.5 µg/L (0.0125 mg/L, nominal) (Experimental)	Nakari and Huhtala, 2010	Not a standard test for the determination of hazard for which emphasis is strongly placed on whole organism studies; Supporting information presented in a non-standard, guideline study (ISO 12890, 1999) with insufficient study details. The solvent dimethyl sulfoxide was used to solubilize test substance into solution. Non-standard dilution water was used. Test concentrations were above the identified water solubility value (0.72 µg/L).
	Fish 30-day ChV = 9.76×10^{-9} mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K_{ow} of 14 for this chemical exceeds the SAR limitation for log K_{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid ChV	Daphnid ChV = 9.91×10^{-8} mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K_{ow} of 14 for this chemical exceeds the SAR limitation for log K_{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
			purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Saltwater Invertebrate ChV	Mysid Shrimp ChV = 2.91×10^{-14} mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K_{ow} of 14 for this chemical exceeds the SAR limitation for log K_{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae ChV	Green Algae ChV = 2.68×10^{-5} mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K_{ow} of 14 for this chemical exceeds the SAR limitation for log K_{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Sediment Dwelling Organisms ChV	Midge (<i>Chironmus riparius</i>) 28-day; there were no treatment-related effects for mean development times, emergence rates and development rates. NOEC = 5,000 mg/kg dry sediment (highest concentration tested) LOEC >5,000 mg/L (Experimental)	Hardy, 2004; Hardy et al., 2012	Adequate, guideline study (according to OECD, OPPTS and GLP); the LOEC and NOEC were determined from visual interpretation of the concentration-response-curve and statistical analysis of the survival/reproduction and dry weight data.
	Oligochaete (<i>Lumbriculus variegates</i>) 28-day; there were no significant treatment-related effects on mean dry weight/oligochaete. NOEC = 5,000 mg/kg dry sediment (highest concentration tested) LOEC >5,000 mg/L (Experimental)	Hardy, 2004; Hardy et al., 2012	Adequate, guideline study (according to OECD, OPPTS and GLP); the LOEC and NOEC were determined from visual interpretation of the concentration-response-curve and statistical analysis of the survival/reproduction and dry weight data.
Earthworm Subchronic Toxicity	Earthworm 28-day survival and reproduction test: NOEC (survival) = 3,720 mg/kg dry soil (highest dose tested); LOEC (reproduction) = 3,720 mg/kg dry soil; NOEC (reproduction) = 1,910 mg/kg dry soil (Experimental)	Hardy, 2011	Adequate, guideline study (according to OECD, OPPTS and GLP).

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		Based on the Level III fugacity models incorporating the located experimental property data, decabromodiphenyl ethane is expected to partition primarily to soil. Decabromodiphenyl ethane is expected to be immobile in soil based on its estimated K_{oc} . Leaching of decabromodiphenyl ethane through soil to groundwater is not expected to be an important transport mechanism. Estimated volatilization half-lives indicate that it will be non-volatile from surface water. Volatilization from dry surface is also not expected based on its vapor pressure. In the atmosphere, decabromodiphenyl ethane is expected to exist solely in the particulate phase, based on its estimated vapor pressure. Particulates may be removed from air by wet or dry deposition.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	EPI; Professional judgment	Cutoff value for nonvolatile compounds based on the ionic nature of the material.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated)	EPI; EPA, 2004	Cutoff value for nonmobile compounds.
	Level III Fugacity Model	Air = <1% Water = 4.5% Soil = 95% Sediment = <1% (Estimated)	EPI	

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Persistence		VERY HIGH: Very high persistence of decabromodiphenyl ethane is expected based on experimental biodegradation data. Decabromodiphenyl ethane was determined to not be readily biodegradable in a 28-day MITI test nor was it inherently degradable in a 90-day aerobic sewage/soil test using pre-exposed inoculum. Decabromodiphenyl ethane is not expected to undergo hydrolysis since it does not contain hydrolysable functional groups. The atmospheric half-life of decabromodiphenyl ethane is estimated to be 4.5 days, although it is expected to exist primarily in the particulate phase in air. Laboratory studies have demonstrated photolysis of decabromodiphenyl ethane, although the rate of this process under environmental conditions has not been established.		
Water	Aerobic Biodegradation	Not inherently biodegradable according to OECD, 2000 guideline study (Measured). The decabromodiphenyl ethane treated bottles evolved an amount of the theoretical inorganic carbon (ThIC) equivalent to that of the untreated controls. Transformation of [¹⁴ C]-labeled decabromodiphenyl ethane was not observed in the 90-d aerobic study.	Hardy, 2004	Adequate, guideline study.
		Not readily biodegradable by activated sewage sludge over 28 days (MITI/OECD 301C Modified MITI) (Measured)	Hardy, 2004	Adequate, guideline study.
	Volatilization Half-life for Model River	>1 year (Estimated)	EPI	
	Volatilization Half-life for Model Lake	>1 year (Estimated)	EPI	
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation	Not biodegradable by anaerobic sewage bacteria within 60 days (Measured)	Schaeffer and Mathews, 2011	Adequate nonguideline study.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Air	Atmospheric Half-life	4.5 days (Estimated)	EPI	
Reactivity	Photolysis	Debrominated congeners identified by a photolytic degradation with a 125W high-pressure mercury lamp experiment using GC/EI-MS and GC/ECNI-MS analysis. (Measured)	Wang et al., 2010	Nonguideline study that demonstrates the potential for both direct and indirect photolysis in the environment. The significance of the laboratory removal rates under environmental conditions cannot be determined.
	Hydrolysis	Not a significant fate process (Estimated)	Wolfe and Jeffers, 2000; Professional judgment	The substance does not contain functional groups that would be expected to hydrolyze readily under environmental conditions.
Environmental Half-Life		>1 year (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.
Bioaccumulation		HIGH: The bioaccumulation hazard designation is estimated based on decabromodiphenyl ethane monitoring data reporting detections in many different species including those higher on the food chain. Although the estimated bioaccumulation factor is low, the persistence of decabromodiphenyl ethane and its detection in many species from different habitats and trophic levels indicates high potential for bioaccumulation hazard in aquatic or terrestrial species.		
	Fish BCF	<2.5 at a concentration of 0.5 mg/L after 8 weeks in carp (<i>Cyprinus carpio</i>) (Measured)	Hardy, 2004	Adequate.
		<25 at a concentration of 0.05 mg/L after 8 weeks in carp (<i>Cyprinus carpio</i>) (Measured)	Hardy, 2004	Adequate.
	BAF	62 (Estimated)	EPI	
	Metabolism in Fish			No data located.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL MONITORING AND BIOMONITORING			
Environmental Monitoring	Decabromodiphenyl ethane was reported in sludge, sediment, and collected from 2001-2002 (Kierkegaard, 2004). Decabromodiphenyl ethane was reported in ambient air samples (Egebäck, 2012), air around the Great Lakes (Venier, 2008) and house dust (Karlsson, 2007; Ali, 2011; Stapleton, 2008; Harrad, 2008, Dirtu, 2011; Takigami, 2009; Dodson et al., 2012). The presence of decabromodiphenyl ethane was reported in Swedish lake sediment (Ricklund et al., 2010). The presence of decabromodiphenyl ethane in sludge from countries worldwide (Ricklund et al., 2008). A review article by Betts (2009) refers to a number of articles reporting decabromodiphenyl ethane in the environment.		
Ecological Biomonitoring	Decabromodiphenyl ethane was detected in walleye (5 samples), emerald shiner (5 samples), goldeye (3 samples), white sucker (5 samples), and burbot (5 samples) from Lake Winnipeg, Canada at concentrations that ranged from below the detection limit up to 2.71 (mean 1.01), 1.51 (mean 0.30), 1.63 (mean 0.62), 0.24 (mean 0.08), and 3.30 (mean 0.66) ng/g lipid weight, respectively. Decabromodiphenyl ethane was found in various tissues of 21 of 26 captive giant and red pandas from China with concentrations ranging from not detected to 863 ng/g lipid weight (87% detection frequency) and not detected to 40.9 ng/g lipid weight (71% detection frequency), respectively, where the limit of detection was 0.053-2.49 ng/g. In wild water birds from China's Pearl River Delta, decabromodiphenyl ethane was detected in the muscle of 28 of 29 birds. It was detected in white-breasted water hen (n=11), slaty-breasted rail (n=5), ruddy-breasted crake (n=5), Chinese-pond heron (n=5), and common snipe (n=3) at concentrations ranging from not detected to 220, 5-62, 4-16, 33-800, and 29-110 ng/g lipid weight, respectively. Decabromodiphenyl ethane was detected in 54% of eggs sampled of five species of wild aquatic birds, one species of wild terrestrial bird, and two species of captive birds collected from North China in 2008. Detected concentrations (ng/g lipid weight) in the eggs ranged from not detected (nd) to 0.9 in Saunder's gull (n=12), nd-0.1 in common tern (n=9), nd-0.9 in Kentish plover (n=8), 0.3-2.2 in black-winged stilt (n=6), 0.4-0.7 in common coot (n=4), 0.9-2.4 in ring-necked pheasant (n=4), 0.1-1.0 in mallard (n=11), and nd-1.7 in swan goose (n=9). Pools of eggs from seven colonies of herring gulls from the Laurentian Great Lakes of North America collected between 1982 and 2006 were analyzed and decabromodiphenyl ethane was detected in two out of seven pools showing concentrations at 9.3 and 44 ng/g w.w. The occurrence and concentrations of decabromodiphenyl ethane detected in herring gull eggs collected from the Great Lakes increased from 2004 to 2006. From 2004 to 2006, the eggs contained concentrations ranging from 13 to about 200 ng/g, lipid weight. In 2005, concentrations were up to 2880 ng/g at two locations of Lakes Michigan and Huron. In a study of 25 peregrine falcon eggs from Canada and Spain, decabromodiphenyl ethane was detected once at 8.2 ng/g fat (LOD = 1.1 ng/g fat, LOQ = 5.2 ng/g fat). Six pooled samples of juvenile common sole from three nursery zones along the French Atlantic coast collected in 2003 and 2004 contained decabromodiphenyl ethane concentrations ranging from 0.18 to 3.90 ng/g fat. In a further study, muscle and liver of the same species (common sole) collected in 2007, 2008 and 2009 from the same three nursery zones plus an		

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	additional one contained mean concentrations in sole muscle samples ranging from 0.9 to 1.9 pg/g w.w. (or from 0.28 to 1.13 ng/g fat), and from <LOD to 14.2 pg/g w.w. (or from <LOD to 1.33 ng/g fat) in liver. In adipose tissue of polar bears (n = 165) from Alaska, the Canadian Arctic, Hudson Bay or the European Arctic, decabromodiphenyl ethane was detected in samples from the Canadian Arctic (frequency of detection: around 10%) and the Hudson Bay (detection frequency: around 3%) but not those from Alaska. In samples of Green mussel (<i>Perna viridis</i>) and Blue mussel (<i>Mytilus edulis</i>) collected from various locations in Cambodia, China, Hong Kong, India, Indonesia, Japan, Malaysia, the Philippines and Vietnam from 2003 to 2008, decabromodiphenyl ethane was detected in 17 out of 67 locations. The concentrations ranged from <0.3 to 22 ng/g fat, with the highest levels detected in mussels from Japan and Korea. Mean concentrations of decabromodiphenyl ethane in three different species of fish Mud carp (<i>Cirrhinus molitorella</i>) (n = 12), Crucian carp (<i>Carassius auratus</i>) (n = 18) and Northern snakehead (<i>Ophicephalus argus</i>) (n = 6) were reported to range from LOD (not given, but LOQ = 0.38 ng/g fat) to 338 ng/g fat. Two invertebrate species, Chinese mystery snail (<i>Cipangopaludina chinensis</i>) (n = 43) and a prawn (<i>Macrobrachium nipponense</i>) (n = 7) and one reptile, Chinese Water Snake (<i>Enhydris chinensis</i>) (n = 2) were also analyzed and the mean concentration in the prawns was 84.3 ng/g fat, while in the remaining species no values were found above the LOD. In wildlife samples collected from southern China, the concentrations of decabromodiphenyl ethane in watercock (<i>Gallicrex cinerea</i>) muscle, liver and kidney were 9.6-16.3, 13.7-54.6 and 24.5-124 ng/g fat, respectively. In carp (<i>Cyprinus sp.</i>), Bighead (<i>Hypophthalmichthys nobilis</i>) and Tilapia (<i>Oreochromis sp.</i>) the concentrations in liver and muscle were all <3.80 ng/g fat. Decabromodiphenyl ethane was detected in tree bark in 2 of 29 locations in southern Arkansas near two brominated flame retardant manufacturing facilities at concentrations of 9.3 and 100 ng/g lipid weight. In samples collected in 2009 from the remote Arctic area of Svalbard, Norway, decabromodiphenyl ethane was detected in 10% of Brunnich's guillemot eggs sampled at a mean concentration of 581 pg/g w.w. In eucalyptus leaves (n=10; mean 20.2 ng/g) and pine needles (n=10; mean dry 21.5 ng/g) from a rural site in southern China (Shi et al., 2009; Betts, 2009; Sagerup et al., 2010; Wu et al., 2010; EFSA, 2012; Law et al., 2006; Hu et al., 2008; Luo et al., 2009; Gao et al., 2009; Gauthier et al., 2009; Zhu and Hites, 2006; Tian et al, 2013).		
Human Biomonitoring	This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Decabromodiphenyl Ether

Screening Level Hazard Summary

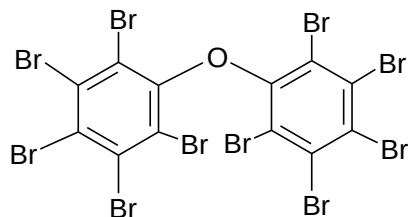
This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity **		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Decabromodiphenyl Ether	1163-19-5	L	M	L	L	H	L	M	L		L	L	L	L	VH	H

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Decabromodiphenyl Ether



CASRN: 1163-19-5

MW: 959.2

MF: C₁₂Br₁₀O

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: O(c1c(c(c(c1Br)Br)Br)Br)Br)c1c(c(c(c1Br)Br)Br)Br)Br

Synonyms: DecaBDE; Benzene, 1,1'-oxybis[2,3,4,5,6-pentabromo-; 1,1'-Oxybis(2,3,4,5,6-pentabromobenzene); Adine 505; BDE 209; BDE-209; Berkflam B; Bis(pentabromophenyl) ether, Bis(pentabromophenyl) oxide; Bromkal 83-0DE; Decabromodiphenyl oxide (DBDPO); DE 83; De 83R; Decabrom; Decabromodiphenyl oxide; Decabromobiphenyl ether; Decabromobiphenyl oxide; FR 300; FR 300BA; PBED 209; Saytex 102; Saytex 102E; Tardex 100
Unverifiable Synonyms: AFR 1021; BR 55N; Bromkal 82-10DE; Caliban F/R-P 39P; DB 10; DB 101; DB 102; DP 10F; EB 10; EB 10FP; EB 10W; EB 10WS; EBR 700; F/R-P 53; Fire Cut 83D; Flame Cut 110R; Flame Cut Br 100; FR 10; FR-PE; FR-PE(H); FRP 53; Nonnen DP 10; Nonnen DP 10(F); PBED 209; Planelon DB; Planelon DB 100; Planelon DB 101; Plasafety EB 10; Plasafety EBR 700

Chemical Considerations: This is a discrete organic chemical with a MW <1,000. EPI v 4.0 was used to estimate physical/chemical and environmental fate values in the absence of experimental data. Measured values from experimental studies were incorporated into the estimations.

Decabromodiphenyl ether (decaBDE) is part of the Polybrominated Diphenyl Ether (PBDEs) Action Plan which addresses: the voluntary phase-out of manufacture and import of decaBDE by manufacturers in the U.S.; development of a Significant New Use Rule and combined Section 4 test rule where the significant new use would be manufacture, (including import) of decaBDE or articles to which decaBDE has been added (EPA, 2009).

Polymeric: No	
Oligomers: Not applicable	
Metabolites, Degradates and Transformation Products: Photodegradation – potential to form lower brominated diphenyl ether congeners and possibly polybrominated dibenzofurans (European Chemicals Bureau, 2002); Fish metabolism - lower brominated diphenyl ether (BDE) congeners a range of penta- to nonaBDEs (with 2,2',4,4',5,6'-hexabromodiphenyl ether being most prevalent) (Noyes et. al., 2011); Anaerobic Biodegradation - lower brominated diphenyl ether congeners (Illinois EPA, 2007); Pyrolysis - polybrominated dibenzofurans and polybrominated dibenzo-p-dioxins (European Chemicals Bureau, 2002)	
Analog: No analog	Analog Structure: Not applicable
Endpoint(s) using analog values: Not applicable	
Structural Alerts: Polyhalogenated aromatic hydrocarbons, immunotoxicity (EPA 2011); test data are available to address this category.	
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2012).	
Hazard and Risk Assessments: Hazard assessment completed by EPA - IRIS Toxicological Review of Decabromodiphenyl ether (2008). Assessments were prepared for decaBDE by the Washington Department of Ecology and Department of Health (2008), Illinois Environmental Protection Agency (2007), Danish Environmental Protection Agency (2007), European Chemicals Bureau (2002), German Federal Ministry of the Environment (2001), and the National Academy of Sciences National Research Council (2000). The Maine Department of Environmental Protection, Safer Alternatives Assessment for Decabromodiphenyl Ether Flame Retardant in Plastic Pallets, includes a Green Screen Assessment of decaBDE (Maine DEP, unpublished). DecaBDE was also part of the High Production Volume Data Summary and Test Plan (EPA, 2005) and the Voluntary Children's Chemical Evaluation Program (EPA, 2012).	

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	300-310 (Measured)	European Chemicals Bureau, 2000; European Chemicals Bureau, 2002	Adequate; consistent values, which span a relatively narrow range, have been reported in a secondary sources.
	305 (Measured)	Lide, 2008	Adequate value cited from standard reference source.
	307 (Measured)	Fu and Suuberg, 2011	Adequate value obtained from differential scanning calorimeter.
Boiling Point (°C)	>320 (decomposes) (Measured)	European Chemicals Bureau, 2002	Adequate; reported in a secondary source.
Vapor Pressure (mm Hg)	3.5×10 ⁻⁸ at 21°C (Measured) Good laboratory practice (GLP) Spinning Rotor Method	Stenzel and Nixon, 1997a; European Chemicals Bureau, 2002	Adequate, guideline study.
	9.02×10 ⁻¹³ at 25°C (Extrapolated) Knudsen Effusion Method	Fu and Suuberg, 2011	Adequate value for low volatility substance; obtained using an indirect measurement technique.
Water Solubility (mg/L)	<1.00×10 ⁻⁴ at 25°C (Measured) GLP Column Elution Method Organisation of Economic Cooperation and Development (OECD) 105 Value reported was the detection limit (<0.1 ppb)	Stenzel and Nixon, 1997b; European Chemicals Bureau, 2002	Adequate; guideline study.
	2×10 ⁻³ to 3×10 ⁻³ (Measured)	European Chemicals Bureau, 2000	Sufficient details were not available to assess the quality of this study reported in a secondary source.
Log K_{ow}	6.27 (Measured) OPPTS 830.7560.GLP Generator Column Method	MacGregor and Nixon, 1997; European Chemicals Bureau, 2002	Adequate, guideline study.
Flammability (Flash Point)	Not flammable (Estimated)	European Chemicals Bureau, 2000	Adequate; value reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis	Polybrominated dibenzo-p-dioxins (PBDDs) and polybrominated dibenzofurans (PBDfFs) are formed by thermal reaction involving a free radical mechanism (Measured)	European Chemicals Bureau, 2000	Supporting information reported in a secondary source.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK_a	Not applicable	Professional judgment	Dissociation is not expected; the chemical does not contain ionizable functional groups.
HUMAN HEALTH EFFECTS			
Toxicokinetics	Although experimental findings in human and animal studies suggest that decaBDE is poorly absorbed following oral and dermal administration, even low levels of decaBDE are physiologically relevant due to its chemical properties. 82.5-91.3% of decaBDE is eliminated from the body in the feces with ≤0.05% excreted in urine. DecaBDE is mainly excreted as unchanged parent compound but may also be excreted in the form of metabolites. Some conversion of parent compound may be mediated by intestinal epithelium or microflora. Monitoring studies in humans, with unknown levels of exposure, demonstrate that decaBDE can be absorbed, distributed to mammary tissue and secreted in human breast milk during lactation.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Dermal Absorption <i>in vitro</i>		Skin of female hairless mice were exposed in a flow-through diffusion cell system to carrier-free ¹⁴C-labeled decaBDE (>98% pure) at doses of 6, 30 or 60 nmol. % absorption was determined at 6, 12, 18 and 24 hours. Most of dose was taken up within the first 6 hours and very little compound was absorbed (0.04-0.34%). Total dose retained in the skin and transported to receptor fluid was 20.5%, 3.3% and 1.9% for 6, 30 and 60 nmol doses, respectively.	EPA, 2008	Reported in a secondary source. The results of this may overestimate the amount of decaBDE that would be absorbed by human skin, as mouse skin has been found to be more permeable to several chemicals.
Absorption, Distribution, Metabolism, and Excretion	Oral	Uptake and disposition of ¹⁴C-DecaBDE after dietary exposure: F344/N male rats fed 238 to 51,000 ppm unlabeled DecaBDE (97.9-99.2% pure) in the diet on days 1-7 and equal doses of ¹⁴C-DecaBDE on day 8. Average daily consumption estimated to be 3,718 mg/kg-day. Analysis of day 12 liver and fat. 91.3% of radioactivity was recovered in the feces 72 hours after exposure. Recovery was not related to administered unlabeled dose. Low level of radioactivity in the liver (mean = 0.02% of the ¹⁴C-dose of 6 groups; range: 0.006 – 0.064% and fat (mean of 0.11% of the ¹⁴C-dose; range: 0.072 – 0.161%)	European Chemicals Bureau, 2002	Study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Uptake and disposition of ¹⁴C-DecaBDE after dietary exposure: F344/N male rats fed 277 or 48,000 ppm unlabeled DecaBDE on days 1-7 and equal amounts of ¹⁴C -DecaBDE on day 8. Doses were equivalent to 22-25 and 4,500-5,000 mg/kg-day; rats were sacrificed 24-, 48-, or 72-hours post-exposure with the radiolabel. Blood, urine, feces, liver, kidney, lung, muscle, fat, skin, brain, gut contents and gut tissue were analyzed. 82.5% to 86.4% of radioactivity was recovered in feces. Recovery was not related to administered unlabeled dose or time of sacrifice. Excretion in the urine was ≤0.01%. Trace levels of radioactivity were found in all major organs and tissues with the highest concentration found in the liver, kidney, lung, skin and adipose tissue. DecaBDE and 3 main metabolites were detected in the feces. % of metabolites increased with increasing DecaBDE concentration in diet, but DecaBDE was primary compound eliminated.	European Chemicals Bureau, 2002	Study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Sprague-Dawley rats given single oral dose of 6 µmol/kg (~2.9 mg/kg) ¹⁴C DBDPO. Major route of excretion (~90% of the dose within 3 days) was via the feces, with only minor amounts (<0.05% of the dose) excreted via urine. Excretion via bile was ~9.5% of dose within 3 days. ~3% of total administered radioactivity was detected in tissues 3 days after dosing (liver (~0.9%), muscle (~0.7%), skin (~0.4%), adipose tissue (~0.3%), colon wall (~0.25%), jejunum wall (~0.05%), jejunum content (~0.05%), with minor amounts (<0.05%) in plasma, kidney, heart, lung, adrenals, testis, red blood cells, thymus and spleen). 8 phenolic metabolites were present in feces, but the majority of radioactivity was identified as unchanged DBDPO. DBDPO was metabolized via debromination.	European Chemicals Bureau, 2002	Study details reported in a secondary source.
		Rats were fed diets containing 1.0 mg/kg-day technical decaBDE for 2 years. 3-fold higher bromine concentrations were measured in adipose tissue, suggesting that bioaccumulation is low but retention in body fat may be pronounced.	Darnerud et al., 2001	Sufficient study details reported in a secondary source; test substance is identified as a commercial product composed of 77.4% BDE209, 21.8% nonaBDE, and 0.8% octaBDE. Analytical methods were not specific for DecaBDE or any specific congener; the bromine levels in adipose tissue cannot be ascribed to any particular congener or mixture of congeners of BDE.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Sprague-Dawley rats (dams, fetuses and/or nursing pups) were administered DecaBDE by gavage at doses of 10, 100, or 1,000 mg/kg-day on gestation days (GD) 6 – lactation day (LD) 4. Levels of DecaBDE were similar in the plasma of dams, fetal litters and neonatal pups following oral doses of 10 mg/kg-day. Plasma concentrations appear to plateau at oral doses of ≥ 10 mg/kg-day. Rats exposed to higher doses of DecaBDE did not have higher levels in their plasma than the low-dose group did. Levels of DecaBDE were lower in the plasma of fetuses and in maternal milk than in plasma of dams, while neonatal plasma levels were similar to or higher than maternal plasma levels. Steady-state plasma levels were achieved within 14 days with adipose half-lives ranging from 0.4 to 2.8 days. Absorption from the gastrointestinal route exhibited zero order uptake kinetics.	Biesemeier et al., 2010	Adequate; corn oil or soyaphospholipon/Lutrol F127-water were used as gavage vehicle for this compound; higher concentrations of DecaBDE were detected in plasma and in milk with corn oil as the vehicle compared to soyaphospholipon/Lutrol F127-water.
Inhalation	Although pulmonary exposure may occur as a result of small particle size ($<5\ \mu\text{m}$), systemic absorption via this route is unknown.	European Chemicals Bureau, 2002	Brief statement reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Other	Disposition of ¹⁴ C-decaBDE after IV dosing; intravenous study in F344/N rats injected with 1.07 mg/kg ¹⁴ C-decaBDE 75% of intra-venous dose was detected in feces and gut contents after 72 hours (suggests biliary excretion). Remaining ¹⁴ C-decaBDE was detected in tissues, mainly in muscle, skin, liver and fat. Trace amounts of radioactivity were detected in urine, the spleen and brain. Excreted material in the feces was primarily unchanged decaBDE.	European Chemicals Bureau, 2002	Study details reported in a secondary source; 9.5% of the administered dose was found in the tail indicating that the dose was delivered incompletely and an unknown amount was given through the tail vein.
		Biliary excretion of ¹⁴ C-decaBDE after IV administration: intravenous study in F344/N rats injected with 0.9 mg/kg ¹⁴ C-decaBDE. 7.17% of administered dose was detected in the bile within 4 hours. Rate of excretion was 2.2% of the dose per hour. Metabolite identification was not carried out in this study	European Chemicals Bureau, 2002	Study details reported in a secondary source; 5.38 % of the administered dose was found in the tail indicating that the dose was delivered incompletely and an unknown amount was given through the tail vein.
		Study conducted to study levels of PBDEs in human breast milk. Mean concentration of decaBDE was 0.9 ng/g lw (1.2% of total PBDEs in the milk), suggesting that some decaBDE is absorbed, distributed to mammary tissue and secreted in human breast milk during lactation.	EPA, 2008	Reported in a secondary source. Information is from monitoring data in human populations. No measured dosing studies have been conducted to determine if BDE-209 distributes to other tissues as well.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Milk samples collected from 40-first time mothers with 8 week old infants. Mean and total concentrations of 12 triBDE through decaBDE congeners were 96 and 50 ng/g lw, respectively. BDE-47 was found at the highest level, followed by hexaBDE and pentaBDE-99 and 100. DecaBDE-209 was a minor congener in breast milk (0.8 and 0.4 ng/g lw, respectively).	EPA, 2008	Reported in a secondary source. Information is from monitoring data in human populations. No measured dosing studies have been conducted to determine if BDE-209 distributes to other tissues as well.
Acute Mammalian Toxicity		LOW: Based on acute oral and dermal LD₅₀ values >2000 mg/kg in rats and rabbits and an acute inhalation LC₅₀ >48.2 mg/L in rats.		
Acute Lethality	Oral	Rat LD ₅₀ >2,000 mg/kg	European Chemicals Bureau, 2002	Reported in a secondary source; guideline study.
		Rat LD ₅₀ >5,000 mg/kg	European Chemicals Bureau, 2002	Reported in a secondary source; nonguideline study; necropsies were not performed.
	Dermal	Rabbit LD ₅₀ >2,000 mg/kg	European Chemicals Bureau, 2002	Reported in a secondary source; nonguideline study. Clinical signs of toxicity were not reported and necropsies were not performed.
	Inhalation	Rat 1-hour LC ₅₀ >48.2 mg/L dust Spartan rats exposed for 1 hour to 2,000 or 48,200 mg/m ³ (2.0 or 48.2 mg/L) dust; No deaths or effect on body weight; Dyspnea, ocular discharge, and eye squint, increased motor activity were observed at 48.2 mg/L.	European Chemicals Bureau, 2002	Reported in a secondary source; nonguideline study. Necropsy was not performed and the particle size distribution was not given.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Single intratracheal injection to male Sprague Dawley rats (n = 50) Dose: 20 mg decaBDE (77.4%) dust (length mean diameter 3.17 µm). Scattered focal aggregates of alveolar macrophages in the lungs showing clear, angulated, cytoplasmic vacuoles; slight thickening of the interalveolar septa.	European Chemicals Bureau, 2002	Reported in a secondary source; nonguideline study.
Carcinogenicity		MODERATE: Based on National Toxicology Program (NTP) determinations of equivocal evidence of carcinogenicity in male mice (increased incidence of hepatocellular adenomas or carcinomas and thyroid gland follicular cell adenomas or carcinomas) and some evidence of carcinogenicity in male and female rats (increased incidences of non-neoplastic nodules in the liver). Classified as “Suggestive evidence of carcinogenic potential” by IRIS.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)			No data located.
	Combined Chronic Toxicity/ Carcinogenicity	2-year carcinogenicity study (dietary) in B6C3F1 mice (50/sex/group). Doses: 0, 25,000, 50,000 ppm Average daily consumption: Males: 0, 3,200 and 6,650 mg/kg Females: 0, 3,760 and 7,780 mg/kg Increased incidence of granulomas in the liver (25,000 ppm, males); centrilobular hypertrophy with enlarged hepatocytes with frothy vacuolated cytoplasm (25,000 and 50,000 ppm, males); follicular cell hyperplasia of the thyroid gland (25,000 and 50,000 ppm, males); and increased incidence of stomach ulcers (50,000 ppm, females). No clinical signs of toxicity and no adverse	NTP, 1986; European Chemicals Bureau, 2002	Study details provided in secondary sources; guideline study in accordance with GLP procedures. NTP concludes that there was <i>equivocal evidence of carcinogenicity</i> for male mice based on increased combined incidence of both hepatocellular adenomas and carcinomas in the low dose group and on thyroid gland follicular cells adenomas or carcinomas (combined) in both groups; results are based on Kaplan Meier estimated tumor incidences at the end of the study after adjusting for early mortality.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	effects on survival, food consumption or body weight. No evidence of carcinogenicity in females. NOAEL: not established LOAEL (systemic): 25,000 ppm (3,200 mg/kg-day) based on increased incidence of non-neoplastic lesions in several tissues in males		
	2-year carcinogenicity study (dietary) in Fisher 344/N rats (50/sex/group) Doses: 0, 25,000, 50,000 ppm Average daily consumption: Males: 0, 1,120 and 2,240 mg/kg Females: 0, 1,200 and 2,550 mg/kg Increased incidence of thrombosis and degeneration in the liver without foci of necrosis associated and fibrosis of the spleen and lymphoid hyperplasia of the mandibular lymph nodes (50,000 ppm, males); hematopoiesis in the spleen (25,000 and 50,000, female); acanthosis of the fore stomach (25,000 and 50,000, males); and dose dependent decreased incidence of C-cell hyperplasia of the thyroid gland (males). No clinical signs of toxicity and no adverse effects on survival, food consumption or body weight. NOAEL (systemic): 25,000 ppm (1,120 and 1,200 mg/kg-day in males and females,	NTP, 1986; European Chemicals Bureau, 2002	Study details provided in secondary sources; guideline study in accordance with GLP procedures. NTP concludes that there was <i>some evidence of carcinogenicity</i> for male and female rats based on increased incidences of non-neoplastic nodules in the liver in the low dose males and high dose males and females.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		respectively) LOAEL (systemic): 50,000 ppm (2,240 and 2,550 mg/kg-day in male and females, respectively) based on neoplastic lesions, degeneration in the liver, spleen fibrosis, lymphoid hyperplasia of the mandibular lymph nodes. LOAEL (local effects): 25,000 ppm based on the slight increase in fore stomach acanthosis		
		2-year carcinogenicity study (dietary) in Sprague-Dawley rats (25/sex/group) Doses: 0, 0.01, 0.1, 1 mg/kg-day. There was no increased incidence of tumors or changes in organ histopathology in treated rats compared to controls. No clinical signs of toxicity and no effects on survival, food consumption, body weight, hematology, urinalysis, clinical chemistry, organ weights.	Kociba et al., 1975; European Chemicals Bureau, 2002	Test substance: 77.4% decaBDE, 21.8% nonaBDE, 0.8% octaBDE.
		Classified as “Suggestive evidence of carcinogenic potential” by EPA IRIS; weight of evidence suggests carcinogenicity and the potential for possible carcinogenic effects in humans.	EPA, 2008	Summary of overall weight of evidence reviewed by IRIS.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Genotoxicity		LOW: Based on negative results for gene mutations in bacterial and mammalian cells and lack of chromosomal aberrations in Chinese hamster ovary (CHO) cells <i>in vitro</i>.		
	Gene Mutation <i>in vitro</i>	Negative in <i>Salmonella typhimurium</i> strains TA98, TA100, TA1535, TA1537 and <i>Escherichia coli</i> WP2 <i>uvrA</i> in the presence or absence of exogenous metabolic activation. No evidence of cytotoxicity.	European Chemicals Bureau, 2002; EPA, 2008	Guideline study in accordance with GLP procedures; study details reported in a secondary source.
		Positive in <i>Salmonella typhimurium</i> strains TA1535, TA98, TA100) in the presence or absence of exogenous metabolic activation. Doses: 50, 150, 500, 1500, 5000 µg/plate	European Chemicals Bureau, 2002	Positive results were only observed at 500 µg/plate and may be a result of the presence of an impurity. In addition, the purity of decaBDE used in the study is unknown (data reported in a secondary source).
		Negative in <i>Saccharomyces cerevisiae</i> with and without metabolic activation	Darnerud et al., 2001	Study details provided in summary reported in a secondary source.
		Negative, mouse lymphoma L 5178 Y/TK+/- assay Doses: 7, 8, 9, 10 µg/plate in dimethyl sulfoxide (DMSO)	European Chemicals Bureau, 2002; EPA, 2008	Guideline study in accordance with GLP procedures. Results may be weighted less heavily due to the narrow range of test concentrations used in the study; study details reported in a secondary source.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative, sister chromatid exchange/chromosomal aberrations in CHO cells in the presence or absence of exogenous metabolic activation. Doses: 50, 100, 200, 500 µg/ml in DMSO	European Chemicals Bureau, 2002; EPA, 2008	Guideline study in accordance with GLP procedures; study details reported in a secondary source.
	Chromosomal Aberrations <i>in vivo</i>	Negative, mammalian chromosomal aberration test in rat bone marrow cells. Doses: 3, 30, 100 mg/kg/day in diet	European Chemicals Bureau, 2002	Limited study details reported in a secondary source.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.

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Decabromodiphenyl Ether CASRN 1163-19-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		LOW: Based on a LOAEL of 500 mg/kg-day in mice for adverse effects on sperm and no adverse reproductive effects following 13 week and 2 year exposures in rats and mice.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects	One generation reproductive study in Sprague Dawley rats (10 males, 20 females in low dose groups; 15 males, 30 females in high dose groups). Doses: 0, 3, 30 or 100 mg decaBDE/kg body weight/day in the diet. Study duration: 60 days prior to mating, 15 days during mating, and throughout gestation and weaning. No adverse effects on fertility NOAEL: 100 mg/kg/day LOAEL: not established as highest dose tested did not produce adverse effects	European Chemicals Bureau, 2002	Reported in a secondary source. Results may be weighted less heavily due to the fact that the highest dose tested did not produce parental toxicity. In addition, individual data were not available (only a summary provided in secondary source); Test substance composition identified as commercial DBDPO (77.4% decaBDE, 21.8% nonaBDE, 0.8% octaBDE).

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Oral gavage study in male CD-1 mice (50/group) Doses: 0, 10, 100, 500 or 1500 mg/kg-day on PNDs 21-70 Reduced amplitude of sperm lateral head displacement, reduced sperm mitochondrial membrane potential, increased sperm H₂O₂ generation. NOAEL: 100 mg/kg-day LOAEL: 500 mg/kg-day	EPA, 2008	Study details reported in a secondary source.
		13 week and 2 year carcinogenicity studies in B6C3F1 mice and F344/N rats did not produce adverse macroscopic or histological changes in the testes, prostate ovaries, or uterus. Doses: 0, 3,100, 6,200, 12,500, 25,000, or 50,000 ppm (13 week study) or 0, 25,000 or 50,000 ppm (2 year studies)	NTP, 1986; European Chemicals Bureau, 2002	Guideline studies reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		28-day oral study in Wistar rats (10/sex/group) Doses: 0, 1.87, 3.75, 7.5, 15, 30, 60 mg/kg-day; 2 doses of 30 mg/kg at 4-hour intervals were used for the 60 mg/kg-day group due to the limited solubility of the test substance; There was a significant dose-dependent change in epididymis weight and seminal vesicle weight, though there were no effects on sperm counts or epididymal sperm morphology. NOAEL = 30 mg/kg-day LOAEL = 60 mg/kg-day (decreased epididymis and seminal vesicle weight)	Van der Ven et al., 2008 (as described in Hardy et al., 2009)	Reported in a review; test substance described as consisting of a composite of equal proportions from 3 manufacturer's products (purity >97%); data were evaluated using benchmark dose analysis; this study was not designed as a reproductive study, and did not evaluate all reproductive parameters.
Developmental Effects		HIGH: A number of rodent developmental neurotoxicity studies addressing decaBDE exposure have been published. The hazard designation for this endpoint is based on the most conservative NOAEL and LOAEL values in the located studies. The adverse effects in these studies were reduced thyroid hormone levels and abnormal behavior. DecaBDE was also developmentally toxic in rats via oral exposure to a low purity product where resorptions were increased at 10 and 100 mg/kg, but not for a high purity product.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Prenatal Exposure	Oral gavage study in pregnant Sprague Dawley rats (n = 20) Dose: 0, 10, 100 or 1,000 mg decaBDE/kg body weight/day Study duration: GD 6-15 Statistically significant increase in resorptions (10 and 100 mg/kg-day) No gross external abnormalities. Significant increase in the number of litters with subcutaneous edema and delayed ossification of normally developed bones of the skull (1,000 mg/kg/day). NOAEL (maternal) = 1,000 mg/kg/day LOAEL (conceptus) = 10 mg/kg/day	European Chemicals Bureau, 2002	Study results may be weighted less heavily due to the low compound purity; test substance identified as a commercial mixture (77.4% decaBDE, 21.8% nonabromodiphenyl ether, 0.8% octabromodiphenyl ether) used in the study), which is lower than the purity of the products currently supplied in the EU. Study details reported in a secondary source.
		Oral gavage study in pregnant Sprague Dawley rats (25/group) Dose: 0, 100, 300 or 1,000 mg/kg/day of decaBDE (purity of 97.34%) Study duration: GD 0-19 No adverse maternal clinical findings or effects on body weight, body weight gain or liver weights. No adverse treatment-related effects on external malformations or variations, skeletal variation or ossification. No adverse effects on fetal weight, sex ratio, total/late resorptions. NOAEL (maternal, developmental): 1,000 mg/kg-day	European Chemicals Bureau, 2002; EPA, 2008	Guideline study in accordance with GLP procedures. Study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Oral gavage (corn oil) study in rats, 0, 100, 300, 1,000 mg/kg/day, (half exposed GD6-20, other half exposed GD6 through LD4). No maternal treatment-related effects on mortality, clinical signs of toxicity, body weight, body weight gain, or food consumption. No effects on gestational or litter parameters (mean gestational length, mean number of pups born, percentage of males at birth, mean live litter size, postnatal survival, mean offspring body weight and weight gains through PND 21). NOAEL = 1,000 mg/kg/day (highest dose tested)	Biesemeier et al., 2010	LOAEL not identified.
		Rat, neurodevelopmental study, oral (gavage) administered 0, 1, 10, 100, or 1,000 mg/kg/day, GD 6 through weaning. No treatment-related neurobehavioral effects were observed (startle response, learning, and memory tests assessed); No changes in were reported in motor activity evaluations at 2, 4, or 6 months of age; No neuropathological or morphometric changes reported. NOAEL = 1,000 mg/kg/day (highest dose tested)	Biesemeier et al., 2011	LOAEL not identified; GLP/guideline compliant study.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Postnatal Exposure/Developmental neurotoxicity	Evaluation of locomotor activity in C57BL6/J mice Dose: 0, 6 or 20 mg/kg on PNDs 2-15 with observation after placement in a novel environment on PND70 and using special functional observational battery No adverse effects on developmental endpoints (on pinnae detachment, incisor eruption, eye opening, vaginal opening or testes descent). Declined locomotor activity in males and females on PND70 (decline was significantly different for males at 6 and 20 mg/kg compared to controls); Decreased % of pups performing the palpebral reflex on PND 14 compared to controls (6 or 20 mg/kg-day); Decreased number of pups (males) adequately performed an effective forelimb grip (PND 14 and 16) compared with same-sex controls (20 mg/kg-day); Increased struggling behavior (males) on PND20, decreased T4 levels (males) on PND70; Decreased T₄ levels (males) on PND70. NOAEL: not established LOAEL: 6 mg/kg-day (based on decreased T4 levels in male mice and effects on locomotor activity in male mice on PND70)	EPA, 2008; Washington DOE, 2008	Study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Single dose gavage in male Sprague Dawley rats (20 rats from 3-5 litters/group) Doses: 0, 6.7 or 20.1 mg/kg on PND3 Dose-related disruption in habituation (changes in locomotion, rearing, total activity) at both doses. NOAEL: Not established LOAEL: 6.7 mg/kg	EPA, 2008	Each dose administered a single time; not a guideline study. Study details reported in a secondary source.
		NMRI male mice (10 mice from 3-5 litters/group) gavaged with decaBDE (99% pure) at 0, 2.22, or 20.1 mg/kg on PNDs3-19 or 0, 1.34, 13.4 or 20.1 mg/kg on PND10. Dose-related disruption in habituation (changes in locomotion, rearing, total activity) at 2, 4, and 6 months following exposure to 20.1 mg/kg on PND3. NOAEL (NMRI mice): 2.22 mg/kg LOAEL (NMRI mice): 20.1 mg/kg	European Chemicals Bureau 2002; EPA, 2008	Each dose administered a single time; not a guideline study. Study details reported in a secondary source.
Neurotoxicity		LOW: There were no neurotoxicity studies addressing decaBDE exposure located. While developmental neurotoxicity studies indicated a potential for hazard, these positive indications do not trigger a hazard potential for adult neurotoxicity. There is no reported evidence to support a hazard potential for adult neurotoxicity for this compound or analogous highly brominated compounds.		
	Neurotoxicity Screening Battery (Adult)	Low potential for neurological effects. (Estimated)	Professional judgment	Estimated based on the absence of structural alerts that have been [experimentally] associated with the adult neurotoxicity endpoint.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects	MODERATE: Based on a LOAEL of 80 mg/kg-day for adverse liver and thyroid effects following a 30-day oral exposure in rats. A NOAEL was not established in the 2-year carcinogenicity study. The LOAEL of 3,200 mg/kg/day yields uncertainty to the dose levels where adverse effects may begin. These subchronic effects appear consistent with the observed chronic effects although the latter were observed at higher doses.		
	30-day dietary study in male Sprague-Dawley rats (number/group not specified) Doses: 0, 100, 1,000, 10,000 ppm (~0, 8, 80, 800 mg/kg/day) Enlarged livers (1,000 ppm); thyroid hyperplasia (1,000 and 10,000 ppm); hepatic centrilobular cytoplasmic enlargement and vacuolisation and renal hyaline degenerative cytoplasmic changes (10,000 ppm). No clinical signs of toxicity and no adverse effects on food consumption, body weight, organ weight or hematological/urinary parameters. NOAEL: 100 ppm (8 mg/kg/day) LOAEL: 1,000 ppm (80 mg/kg/day) based on incidence of enlarged livers	European Chemicals Bureau, 2002	Results may be weighted less heavily due to the low compound purity (77.4% decaBDE - 21.8% nonabromodiphenyl oxide) used in the study, which is lower than the purity of the products currently supplied in the EU; study details reported in a secondary source; Design for the Environment (DfE) Alternatives Assessment criteria values are tripled for chemicals evaluated in 28-day studies; the LOAEL of 80 mg/kg-day falls within the Moderate hazard criteria.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	14-day dietary study in B6C3F1 mice and F344/N rats (5/sex/group). Doses: 0, 5,000, 10,000, 20,000, 50,000, or 100,000 ppm decaBDE (99% purity). Estimated average doses: Mice: 0, 1,027, 2,143, 4,246, 10,536, or 20,994 mg/kg-day in male mice and 0, 1,146, 2,286, 4,627, 11,348, or 23,077 mg/kg-day in female mice. Rats: 0, 472, 928, 1,846, 4,569, or 9,326 mg/kg-day in male rats and 0, 538, 1,061, 2,137, 5,323, or 10,853 mg/kg-day in female rats. No adverse effects on health, survival body weight, clinical signs or gross pathology. NOAEL (mice): 20,994 mg/kg-day in male mice and 23,077 mg/kg-day in female mice LOAEL: Not established, as highest dose tested did not produce adverse effects NOAEL (rats): 9,326 mg/kg-day in male rats and 10,853 mg/kg-day in female rats LOAEL: Not established, as highest dose tested did not produce adverse effects	European Chemicals Bureau, 2002; Maine, unpublished; EPA, 2008	Guideline study in accordance with GLP procedures; study details reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	13-week dietary study in B6C3F1 mice and F344/N rats (10/sex/group) Doses: 0, 3,100, 6,200, 12,500, 25,000, 50,000 ppm Estimated average doses: Mice: 0, 666, 1,355, 2,659, 5,278, or 10,233 mg/kg-day in males and 0, 702, 1,437, 2,899, 5,687, or 11,566 mg/kg-day in females Rats: 0, 191, 372, 781, 1,536, or 3,066 mg/kg-day in male rats and 0, 238, 504, 967, 1,955, or 3,944 mg/kg-day in female rats No adverse effects on health, survival body weight, clinical signs or gross pathology. NOAEL (mice): 10,233 mg/kg-day in males and 11,566 mg/kg-day in females LOAEL (mice): Not established, as highest dose tested did not produce adverse effects NOAEL (rats): 3,066 mg/kg-day in male rats and 3,944 mg/kg-day in female rats LOAEL (rats): Not established, as highest dose tested did not produce adverse effects	European Chemicals Bureau, 2002; Maine, unpublished; EPA, 2008	Guideline study in accordance with GLP procedures; study details reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	28-day dietary study in F344/N rats (10/sex/group) Doses: 0, 100, 1,000 ppm (0, 7, 70 mg/kg/day (M); 0, 8, 80 mg/kg/day (F)) No adverse effects on health, survival body weight, food consumption, behavior, or gross pathology. NOAEL: 1,000 ppm (70 or 80 mg/kg-day for males and females, respectively) LOAEL: Not established, as highest dose tested did not produce adverse effects	European Chemicals Bureau, 2002; EPA, 2008	Guideline study; study details reported in a secondary source; DfE Alternatives Assessment criteria values are tripled for chemicals evaluated in 28-day studies; while the LOAEL was not established, the NOAEL of ~70-80 mg/kg-day (highest dose tested) falls within the Moderate hazard criteria (30 - 300 mg/kg-day); it is uncertain if repeated dose effects may occur within this range.
	28-day oral study in Wistar rats (10/sex/group) Doses: 0, 1.87, 3.75, 7.5, 15, 30, 60 mg/kg-day; 2 doses of 30 mg/kg at 4-hour intervals were used for the 60 mg/kg-day group due to the limited solubility of the test substance; There were no changes in appearance, behavior, food consumption or body weight reported; Occasional slight hepatic centrilobular hypertrophy occurred in male rats; there were no changes in plasma alanine aminotransferase in males or females and no changes in plasma alkaline phosphatase (ALP) in male rats reported; decreased ALP levels were reported in female rats at the highest dose; increased hepatic CYP1AmRNA, CYP2B mRNA, CYP1A1 protein, and 7-pentoxoresorufin O-deethylase (EROD) activity was reported	Van der Ven et al., 2008 (as described in Hardy et al., 2009)	Study reported in a review; test substance described as consisting of a composite of equal proportions from 3 manufacturer's product (purity >97%); data were evaluated using benchmark dose analysis; DfE Alternatives Assessment criteria values are tripled for chemicals evaluated in 28-day studies; the LOAEL of 60 mg/kg-day falls within the Moderate hazard criteria; however, these effects may be the result of an adaptive response by the liver and not considered adverse.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	in both males and females in the 60 mg/kg-day group; T3 levels were increased in female rats, but not male rats in the high dose group; there was no effect on T4 levels in males. There were also no histological or weight changes in the thyroids or pituitaries reported; There was decreased adrenal CYP17 adrenal activity observed in females but not males. No other histopathological or weight changes in the adrenal glands were reported In the absence of histopathological alterations, changes in hepatic enzymes may be the result of an adaptive response by the liver. NOAEL = 30 mg/kg-day LOAEL = 60 mg/kg-day (changes in hepatic enzyme and enzyme mRNA levels)		

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	2-year carcinogenicity study (dietary) in B6C3F1 mice (50/sex/group) Doses: 0, 25,000, 50,000 ppm Average daily consumption: Males: 0, 3,200 and 6,650 mg/kg/day Females: 0, 3,760 and 7,780 mg/kg/day Increased incidence of granulomas in the liver (25,000 ppm, males); centrilobular hypertrophy with enlarged hepatocytes with frothy vacuolated cytoplasm (25,000 and 50,000 ppm, males); follicular cell hyperplasia of the thyroid gland (25,000 and 50,000 ppm, males); increased incidence of stomach ulcers (50,000 ppm, females). No clinical signs of toxicity and no adverse effects on survival, food consumption or body weight. NOAEL: Not established LOAEL: 25,000 ppm (3,200 mg/kg-day) based on increased incidence of non neoplastic lesions in several tissues	European Chemicals Bureau, 2002; EPA, 2008	Guideline study in accordance with GLP procedures; study details reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	2-year carcinogenicity study (dietary) in Fisher 344/N rats (50/sex/group) Doses: 0, 25,000, 50,000 ppm Average daily consumption: Males: 0, 1,120 and 2,240 mg/kg Females: 0, 1,200 and 2,550 mg/kg Increased incidence of thrombosis and degeneration in the liver without foci of necrosis associated, fibrosis of the spleen and lymphoid hyperplasia of the mandibular lymph nodes (50,000 ppm, males); hematopoiesis in the spleen (25,000 and 50,000, female); acanthosis of the fore stomach (25,000 and 50,000, males); dose-dependent decreased incidence of C-cell hyperplasia of the thyroid gland (males). No clinical signs of toxicity and no compound-related effects on survival NOAEL (systemic): 25,000 ppm (1,120 mg/kg-day) LOAEL (systemic): 50,000 ppm (2,240 mg/kg-day) based on neoplastic lesions, degeneration in the liver, spleen fibrosis, lymphoid hyperplasia of the mandibular lymph nodes LOAEL (local effects): 25,000 ppm (1,120 mg/kg-day) based on the slight increase in fore stomach acanthosis	European Chemicals Bureau, 2002; EPA, 2008	Guideline study in accordance with GLP procedures; study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		4-day oral gavage study in Long-Evans female weanling rats (8/group). Doses: 0, 0.3, 1, 3, 10, 30, 60 or 100 mg/kg-day No dose-related effects on body weight, liver weight or changes in TSH, T3 or T4 levels. NOAEL: 100 mg/kg/day LOAEL: not established, as highest dose tested did not produce adverse effects	EPA, 2008	A 4-day exposure study may not be a good indicator of chronic exposure effects; study details reported in a secondary source.
		In chronic dietary studies in male rats, decaBDE has caused histological changes in lymphoid organs (spleen, mandibular lymph nodes) at 2,240 mg/kg-day.	EPA, 2008	Study details reported in a secondary source.
		No cytotoxic effects in splenocytes from C57BL/6 mice incubated in culture with 3 µmol/L decaBDE (purity not specified). No attenuation of interleukin-2-receptor α chain (CD25) expression (demonstrating a lack of effect on the immune system in an immunosuppressive manner).	EPA, 2008	Study details reported in a secondary source.
Skin Sensitization		LOW: Based on negative results for skin sensitization in guinea pigs and human volunteers.		
	Skin Sensitization	Negative, guinea pigs	European Chemicals Bureau, 2002	Reported in a secondary source; study was performed using a mixture of polybrominated diphenyl oxides (commercial octaBDE) which comprised of <3% decaBDE.
		Negative, human volunteers	European Chemicals Bureau, 2002	Reported in a secondary sources; concentrations tested were very low (2-5%).

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: DecaBDE is a mild eye irritant in rabbits.		
	Eye Irritation	Transient, mild irritation, rabbits (reversible in 48 hours)	European Chemicals Bureau, 2002	Reported in a secondary source; guideline study in accordance with GLP procedures.
Dermal Irritation		LOW: DecaBDE is a slight skin irritant in humans.		
	Dermal Irritation	Non-irritant, rabbit	European Chemicals Bureau, 2002	Reported in a secondary source; guideline study using commercial decaBDE as dry solid.
		Slight irritation, human volunteers	European Chemicals Bureau, 2002	Reported in a secondary source.
Endocrine Activity		Limited studies were located on the ability of decaBDE to interact with the endocrine system. However, some metabolites of decaBDE are known to produce estrogenic effects. In addition, decaBDE is listed as a potential endocrine disrupter on the EU Priority List of Suspected Endocrine Disrupters and on the Red List of chemicals (EU, 2012; CPA, 2009).		
		<i>Pimephales promelas</i> (fathead minnows) fed 3 or 300 ng/g bw-day BDE-209 or 15 µg/g bw-day 6-propyl-2-thiouricil (PTU) as a positive control for 28 days followed by a 14 day depuration. 3 ng/g bw-day: 53% decline in TT4; 46% decline in TT3 300 ng/g bw-day: 59% decline in TT4; 62% decline in TT3 Both doses: 62% reduced brain deiodinase activity and elevated relative mRNA expression in genes associated with thyroid pathways. Decreased gonadal-somatic index and increased mortality.	Noyes et al., 2013	Study details reported in a primary source. It is not known if the parent BDE-209 or its metabolites were driving the effects.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	<i>Pimephales promelas</i> (fathead minnows) fed 0.16 µg/g BDE-209 for 28 days. Reduced rates of outer and inner ring deiodination of thyroxine (74%). Significantly increased thyroid follicular epithelial cell heights	Noyes et al., 2011	Study details from primary source.
	Ongoing unpublished studies at the University of Southern Maine indicate effects on blood concentrations of hormone T₄ in male mice and no effects on treated females.	Maine, unpublished	This is an ongoing study at the University of Southern Maine. No definitive conclusions regarding the potential for decaBDE to produce endocrine disruption have been made.
	DecaBDE is listed as a potential endocrine disruptor on the EU Priority List of Suspected Endocrine Disruptors.	European Commission, 2012	“Potential for endocrine disruption. In vitro data indicating potential for endocrine disruption in intact organisms. Also included effects in-vivo that may, or may not, be endocrine disruption-mediated. May include structural analyses and metabolic considerations”.
	4-day oral gavage study in Long-Evans female weanling rats (8/group). Doses: 0, 0.3, 1, 3, 10, 30, 60 or 100 mg/kg-day No dose-related effects on TSH, T3 or T4 levels. NOAEL: 100 mg/kg/day LOAEL: not established, as highest dose tested did not produce adverse effects	EPA, 2008	A 4-day exposure study may not be a good indicator of chronic exposure effects; study details reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	28-day oral study in Wistar rats (10/sex/group) Doses: 0, 1.87, 3.75, 7.5, 15, 30, 60 mg/kg-day; 2 doses of 30 mg/kg at 4-hour intervals were used for the 60 mg/kg-day group due to the limited solubility of the test substance; T3 levels were increased in female rats, but not male rats in the high dose group; there was no effect on T4 levels in males. There were also no histological or weight changes in the thyroids or pituitaries reported; There was decreased adrenal CYP17 adrenal activity observed in females but not males. No other histopathological or weight changes in the adrenal glands were reported.	Van der Ven et al., 2008 (as described in Hardy et al., 2009)	Study reported in a review; test substance describes as consisting of a composite of equal proportions from 3 manufacturer's product (purity >97%).
	2-year carcinogenicity study (dietary) in Sprague-Dawley rats (25/sex/group) Doses: 0, 0.01, 0.1, 1 mg/kg-day; There were no changes in organ histopathology in treated rats compared to controls; No clinical signs of toxicity and no effects on survival, food consumption, body weight, hematology, urinalysis, clinical chemistry, organ weights.	Kociba et al., 1975; European Chemicals Bureau, 2002	Test substance: 77.4% decaBDE, 21.8% nonaBDE, 0.8% octaBDE.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Immunotoxicity		Histological changes in lymphoid organs occurred at 2,240 mg/kg-day in a chronic study of rats.		
	Immune System Effects	In chronic dietary studies in male rats, decaBDE has caused histological changes in lymphoid organs (spleen, mandibular lymph nodes) at 2,240 mg/kg-day.	EPA, 2008	Study details reported in a secondary source.
		No cytotoxic effects in splenocytes from C57BL/6 mice incubated in culture with 3 μmol/L decaBDE (purity not specified).	EPA, 2008	Study details reported in a secondary source.
		No attenuation of interleukin-2-receptor α chain (CD25) expression (demonstrating a lack of effect on the immune system in an immunosuppressive manner).		
ECOTOXICITY				
Aquatic Toxicity				
ECOSAR Class				
Acute Toxicity		LOW: The log K _{ow} of the compound (6.27) exceeds the ECOSAR cutoff value of 5.0 for acute endpoints and therefore, no effects at saturation (NES) are predicted. Although experimental studies were located for fish and green algae, they were considered to be inadequate due to deviations from standard protocols and resulting toxicity values that exceed the compound's water solubility.		
Fish LC ₅₀		<i>Oryzias latipes</i> 48 hour LC ₅₀ >500 mg/L (Experimental)	European Chemicals Bureau, 2002	OECD guidelines for acute aquatic toxicity (203) state that the preferred exposure duration is 96 hours.
		96 hour LC ₅₀ = 0.129 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	The log K _{ow} exceeds the ECOSAR cutoff value of 5.0 for acute endpoints and therefore, NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid LC₅₀	48 hour LC ₅₀ = 0.137 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	The log K _{ow} exceeds the ECOSAR cutoff value of 5.0 for acute endpoints and therefore, NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Other Freshwater Invertebrate LC₅₀	Mysid shrimp 96 hour LC ₅₀ = 0.006 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	The log K _{ow} exceeds the ECOSAR cutoff value of 5.0 for acute endpoints and therefore, NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae EC₅₀	<i>Skeletonema costatum</i> , <i>Thalassiosira pseudonana</i> 72 hour EC ₅₀ >1 mg/L (Experimental)	European Chemicals Bureau, 2002	Reported in a secondary source; the reported toxicity limit exceeds the compound's water solubility.
	<i>Chlorella sp.</i> 96 hour EC ₅₀ >1 mg/L (Experimental)	European Chemicals Bureau, 2002	Reported in a secondary source, the reported toxicity limit exceeds the compound's water solubility.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	96 hour EC ₅₀ = 0.416 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	The log K _{ow} exceeds the ECOSAR cutoff value of 5.0 for acute endpoints and thus, NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Chronic Aquatic Toxicity	LOW: Based on estimated values for fish, daphnia and algae that exceed the water solubility and are therefore predicted to have NES. Although not currently applicable to DfE aquatic toxicity criteria, a chronic dietary fish study identified decreased thyroid hormone, deiodinase activity and gonad size, plus increased mortality, after dietary exposure to part per billion doses of decaBDE.		
Fish ChV	<i>Pimephales promelas</i> (fathead minnows) fed 3 or 300 ng/g bw-day BDE-209 or 15 µg/g bw-day 6-propyl-2-thiouricil (PTU) as a positive control for 28 days followed by a 14 day depuration. 3 ng/g bw-day: 53% decline in TT4; 46% decline in TT3 300 ng/g bw-day: 59% decline in TT4; 62% decline in TT3 Both doses: 62% reduced brain deiodinase activity and elevated relative mRNA expression in genes associated with thyroid pathways. Decreased gonadal-somatic index and increased mortality.	Noyes et al., 2013	Study details reported in a primary source. It is not known if the parent BDE-209 or its metabolites were driving the effects.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	30-day ChV = 0.018 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	The ChV value exceeds the water solubility by more than a factor of 10, and therefore, NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid ChV	ChV = 0.031 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	The ChV value exceeds the water solubility by more than a factor of 10 and therefore, NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Saltwater Invertebrate ChV	Mysid shrimp ChV = 0.00015 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	This chemical may not be soluble enough to measure this predicted effect. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Green Algae ChV	ChV = 0.324 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	The ChV value exceeds the water solubility by more than a factor of 10, and therefore, NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Sediment Dwelling Organisms ChV	<i>Lumbriculus variegatus</i> NOEC $\geq$ 5,000 mg/kg dry weight based on nominal concentrations (Experimental)	European Chemicals Bureau, 2002	Reported in a secondary source; guideline study (American Society for Testing and Materials 1706-95b and OPPTS No. 850.1736). DfE has not established hazard criteria for studies based on sediment concentrations nor sediment dwelling organisms at the time of this report.
Terrestrial Ecotoxicity			
Chicken embryo toxicity	Chicken embryo LD ₅₀ = 740 ng/g ww; egg injection study (Experimental)	Sifleet, 2009	Test substance identified as BDE-209.
Earthworm Subchronic Toxicity	56-day NOEC (survival or reproduction) >4,910 mg/kg dry weight using nominal concentrations (Experimental)	European Chemicals Bureau, 2002	Reported in a secondary source; guideline study (OECD 207 test guideline).

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The transport evaluation for decaBDE is based on both estimated and experimental physical and chemical properties. Based on the Level III fugacity models incorporating the located experimental property data, decaBDE is expected to partition primarily to soil. It is not expected to dissociate at environmentally-relevant pHs. DecaBDE is expected to have low mobility in soil based on its estimated K_{oc}. Therefore, leaching of decaBDE through soil to groundwater is not expected to be an important transport mechanism. Estimated volatilization half-lives for a model river indicate that it will have moderate potential to volatilize from surface water. Volatilization potential from a model lake is expected to be low. In the atmosphere, decaBDE is expected to exist primarily in the particulate phase. Particulate phase decaBDE will be removed from air by wet or dry deposition.		
	Henry's Law Constant (atm-m³/mole)	4.4×10 ⁻⁴ at 25°C (Estimated)	EPI	Value was obtained from the measured vapor pressure and water solubility.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	2.8×10 ⁵ (Estimated)	EPI	
	Level III Fugacity Model	Air: <1% (Estimated) Water = 1.5% Soil = 63% Sediment = 35%	EPI	In addition to EPI estimates, these results were obtained by using the measured vapor pressure, log K_{ow} , and water solubility.
Persistence		VERY HIGH: The persistence potential for decaBDE is Very High; it is not expected to degrade rapidly under aerobic conditions. Slow degradation through debromination may occur under anaerobic conditions. The anaerobic experimental results are indicative of limited removal but at very low rates that are possibly background level degradation under the test conditions. Experimental studies indicate no degradation after 2 weeks in a ready biodegradation test, but no data were located for soil or water. Results from biodegradation estimation models also suggest decaBDE is recalcitrant under aerobic conditions. Nonguideline experimental studies indicate decaBDE may be capable of undergoing limited anaerobic biodegradation; however the removal rate also suggests Very High persistence. The initially formed degradation products are also expected to be persistent. DecaBDE is not expected to hydrolyze in the environment based on experimental data. Experimental data indicate that decaBDE may undergo photolysis to debrominated transformation products. Data concerning the kinetics of these photolysis reactions were not located.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Water	Aerobic Biodegradation	No degradation after 2 weeks (Measured) OECD Test Guideline 301C	MITI, 1998	Guideline study; reported 80% retention in water (control) and sludge. Study hypothesized that loss of compound is due to decaBDE converting to an intermediate product under the study conditions.
	Volatilization Half-life for Model River	7.3 hours (Estimated)	EPI	Estimation model was calculated using all applicable measured input values and the Henry's Law Constant obtained from the measured vapor pressure and water solubility.
	Volatilization Half-life for Model Lake	340 days (Estimated)	EPI	Estimation model was calculated using all applicable measured input values and the Henry's Law Constant obtained from the measured vapor pressure and water solubility.
Soil	Aerobic Biodegradation	BDE 209 (decaBDE) showed no significant degradation after 160 days (Measured)	Nyholm et al., 2010	Nonguideline study, although the low rate of removal is consistent with aerobic degradation experiments in water.
		Soils spiked with 1, 10, and 100 mg/kg BDE 209 (decaBDE) and incubated for up to 180 days; No degradation of BDE 209 was observed. (Measured)	Liu et al., 2011	Nonguideline study, although the low rate of removal is consistent with other aerobic degradation experiments.
	Anaerobic Biodegradation	No degradation after 4 months in incubated, acclimated anaerobic sediments (Measured)	European Chemicals Bureau, 2002	Reported in a secondary source with limited study details.
		<1% degradation after 32 weeks in anaerobic river sediments (Measured)	Schaefer and Siddiqui, 2001; European Chemicals Bureau, 2002	Reported in a secondary source. Study used C-14 labeled test substance, analyzed by high performance liquid chromatography.

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Decabromodiphenyl Ether CASRN 1163-19-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		DecaBDE in sewage sludge was broken down into octa- and nona- BDEs; study run with and without organic chemical primers; half-life ~700 days with primers, longer without primers. (Measured)	Gerecke et al., 2005 and Gerecke et al., 2006 (as described in Illinois EPA, 2007)	Reported in a secondary source with limited study details.
		Breakdown to hexa- and nona-BDEs in anaerobic sediment cultures after 3.5 years. Half-life = 10 years. Mole fraction distribution of presumed metabolites with ≤ 9 Br is $<3\%$ (Measured)	Nies et al., 2005 (as described in Illinois EPA, 2007)	Reported in a secondary source with limited study details.
		Rapid breakdown to nonaBDEs in anaerobic sediment cultures in the presence of organic solvents. (Measured)	Skoczynska et al., 2005 (as described in Illinois EPA, 2007)	Reported in a secondary source with limited study details. Primary source not available to be verified.
		Debromination of decaBDE was found to occur in species specific studies with <i>Sulfurospillum multivorans</i> to hepta- and octa- BDEs in the presence of trichloroethylene. <i>Dehalococcoides</i> species were not able to debrominate decaBDE. (Measured)	He et al., 2006 (as described in Illinois EPA, 2007)	Reported in a secondary source with limited study details.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	320 days (Estimated)	EPI	
Reactivity	Photolysis	Degradation to lower brominated diphenyl ether congeners and sometimes polybrominated dibenzofurans reported under varying conditions in several laboratory studies using UV and natural sunlight. (Measured)	European Chemicals Bureau, 2002	Based on a summary of several laboratory studies under varying conditions, using UV and natural light.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		DecaBDE absorbed into clays and organic rich sediments experienced debromination in UV and natural light. Debromination of decaBDE absorbed on three metal oxides did not occur. (Measured)	Ahn et al., 2006 (as described in Illinois EPA, 2007)	Reported in a secondary source with limited study details.
		No evidence of light-mediated debromination of decaBDE applied to soil in sewage sludge in a field study. The soils were plowed under which may have impacted sunlight exposure. (Measured)	Sellstrom et al., 2005 (as described in Illinois EPA, 2007)	Reported in a secondary source with limited study details.
		No significant degradation of BDE-209 (decaBDE) occurred in personal vehicle dust samples after 56 days of constant UVA irradiation under laboratory conditions; however degradation occurred when the study was performed with decaBDE absorbed to sodium sulfate. (Measured)	Lagalante et al., 2011	Nonguideline study demonstrating the relative stability of decaBDE under the test conditions.
		BDE-209 (decaBDE) spiked and non-spiked (natural) dust samples were exposed to sunlight for 200 cumulative hours. <38% of the original decaBDE mass was degraded in the spiked dust, 25% of which could not be accounted for and was lost to unknown pathways and/or products. The remaining 13% was accounted for by the formation of lower brominated congeners. (Measured)	Stapleton and Dodder, 2008	Nonguideline study demonstrating the potential for photolytic degradation of similar highly brominated materials.
	Hydrolysis	No degradation at pH 5 and 7 at 100°C after six weeks. (Measured)	European Chemicals Bureau, 2002	Reported in a secondary source.

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Decabromodiphenyl Ether CASRN 1163-19-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Environmental Half-life		360 days (Estimated)	PBT Profiler, Professional judgment	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.
Bioaccumulation		HIGH: Based on estimated BAF values suggesting that the potential for bioaccumulation is high and located monitoring data indicating that decaBDE has been detected in higher trophic level organisms. DecaBDE degradation, transformation and metabolism products also contribute to the high bioaccumulation hazard designation. These compounds are lower brominated congeners and also have been detected in monitoring studies (ATSDR, 2004).		
	Fish BCF	≤5 to ≤50 (Measured) 6 week exposure in <i>Cyprinus carpio</i> with sample concentrations of 60 ppb and 6 ppb, respectively using a method identified as flow-through bioaccumulation test of a chemical substance in fish or shellfish	MITI, 1998 (as described in European Chemicals Bureau, 2002); J-Check, 2013	Nonguideline study of a commercial product mixture containing ≥75% decaBDE, approximately 17% nonaBDE and 8% octaBDE.
	BAF	49,000 (Estimated)	EPI	
		0.0% uptake from diet after 90 days in <i>Cyprinus carpio</i> (Measured)	Stapleton et al., 2004	Adequate, nonguideline study.
		0.005% uptake from diet after 120 days in <i>Oncorhynchus mykiss</i> (Measured)	Kierkegaard et al., 1999	Adequate, nonguideline study.
	Metabolism in Fish	Little or no uptake from water phase exposure; limited uptake (~0.02-0.13%) observed when exposed from food, after 120-day exposure period. (Measured)	European Chemicals Bureau, 2002	Reported in a secondary source.
		Found to be metabolized in juvenile fathead minnows and to accumulate after 28-day treatment at 9.8 µg/g food. A range of penta- to octaBDEs metabolites were detected with 2,2',4,4',5,6'-hexabromodiphenyl ether being most prevalent. (Measured)	Noyes et. al., 2011	Adequate, nonguideline study.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		<i>In vitro</i> metabolism of BDE-209 (decaBDE) by microsomal fractions of Chinese sturgeon found that BDE-209 was biotransformed in liver. Debrominated products: BDE-126, BDE-154, BDE-188, BDE-184, BDE-183, BDE-202, BDE-201, and BDE-204/197; after incubation. (Measured) A physiologically based pharmacokinetic model (PBPK) of BDE-209 in Chinese sturgeon was used to develop a Bayesian hierarchical model to estimate partition coefficients. The low calculated partition ratios from blood to tissues would lead to high bioaccumulation of BDE-209, especially in absorbing organs. (Estimated)	Wan et al., 2013	
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		Detected in surface water particulates; wet and dry deposition samples; sludge and effluents from wastewater treatment plants; sediments and soils worldwide; urban, rural, and suburban atmospheric air; indoor air and house dust (HSDB, 2011; Dodson et al., 2012).		
Ecological Biomonitoring		Detected in tree bark; fish and shellfish worldwide; in cats; owl and peregrine falcon eggs in Belgium and Sweden, respectively (HSDB, 2011); peregrine falcon eggs in California (Park et al., 2009); birds of prey, herbivore and predator mammals, marine fish, marine invertebrates, marine mammals, marine/aquatic/other birds and vegetation (Canada, 2010); eucalyptus leaves and pine needles (Tian, 2013).		
Human Biomonitoring		Detected in breast milk (HSDB, 2011); serum (Thuresson, 2006; He et al., 2013) and blood (EPA, 2008). This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Ethylene Bis-Tetrabromophthalimide (EBTBP)

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

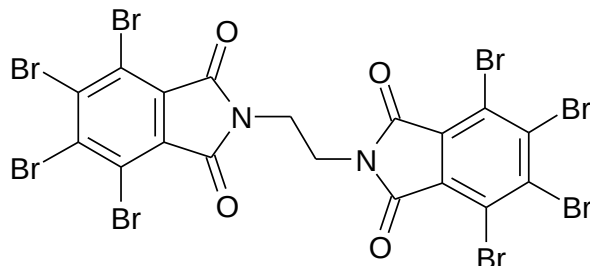
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^s Based on analogy to experimental data for a structurally similar compound.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Ethylene Bis-Tetrabromophthalimide	32588-76-4	L	M	L	L	M^s	L	L	L		VL	VL	L	L	VH	H

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Ethylene Bis-Tetrabromophthalimide (EBTBP)



CASRN: 32588-76-4

MW: 951.5

MF: C₁₈H₄Br₈N₂O₄

Physical Forms: Solid
Neat:

Use: Flame retardant

SMILES: O=C1N(C(=O)c2c(c(c(c(c2)Br)Br)Br)Br)CCN1C(=O)c2c(c(c(c(c2)Br)Br)Br)Br)C1=O

Synonyms: 1H-Isoindole-1,3(2H)-dione, 2,2'-(1,2-ethanediyl)bis[4,5,6,7-tetrabromo-; Saytex BT 93; Ethylene bis(tetrabromophthalimide); 2,2'-(1,2-Ethanediyl)bis(4,5,6,7-tetrabromo-1H-isoindole-1,3(2H)-dione); N,N'-Ethylenebis(3,4,5,6-tetrabromophthalimide); EBTPI

Chemical Considerations: This alternative is a discrete organic chemical with a MW <1,000. EPI v 4.1 was used to estimate physical-chemical and fate values. No measured values were incorporated due to an absence of experimental data.

Polymeric: No

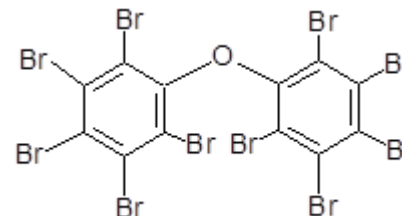
Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: None

Analog: Decabromodiphenyl Ether (CASRN 1163-19-5)

Endpoint(s) using analog values: Developmental Effects

Analog Structure:



Decabromodiphenyl Ether (CASRN 1163-19-5)

Structural Alerts: None identified

Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community & IUCLID (Pakalin et al., 2007)

Hazard and Risk Assessments: Risk assessment completed for Ethylene bis-tetrabromophthalimide (EBTBP) by Denmark in 2007 (Stuer-Lauridsen, 2007) and a dossier was completed by Albemarle Corporation for EPA's High Production Volume Program (EPA, 2008a).

Ethylene Bis-Tetrabromophthalimide CASRN 32588-76-4

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	446 (Measured)	NIEHS, 1999	Nonguideline study, yet established method considered sufficient for a screening assessment.
Boiling Point (°C)	>300 (Estimated)	EPI; EPA, 1999	Cutoff value for high boiling point compounds according to High Production Volume (HPV) assessment guidance.
Vapor Pressure (mm Hg)	0.0000017 (Measured) Reported as 2.27×10^{-4} Pa at 20°C using the spinning rotor gauge method Organisation of Economic Cooperation and Development (OECD) 104	Lezotte et al., 2005	Guideline study with commercial product. Purity of the sample was not provided or determined.
Water Solubility (mg/L)	$<10^{-3}$ (Estimated)	EPI; EPA, 1999	Cutoff value for non-soluble compounds according to HPV assessment guidance.
Log K_{ow}	9.8 (Estimated)	EPI; EPA, 1999	Near cutoff value for non-soluble compounds according to HPV assessment guidance.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK_b	5.48 (Estimated)	SPARC	

Ethylene Bis-Tetrabromophthalimide CASRN 32588-76-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		Ethylene bis-tetrabromophthalimide as a neat material is estimated to not be absorbed by any route of exposure and is expected to have poor absorption for all routes when in solution. Ethylene bis-tetrabromophthalimide is distributed through tissues, but dissipates after exposure ceases; it is excreted primarily in the feces and urine. There were no data located regarding absorption or metabolism.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption through all routes as neat material; poor absorption through all routes when in solution (Estimated by analogy)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
		Rat, oral (gavage), 14-day exposure to 14C-labeled BT93; excreted primarily in the feces (65% of total dose) and urine (15% of total dose); minor amounts of 14C-label was found in tissues, but dissipated within the 30-day withdrawal period.	NIEHS 1999; IUCLID 2000	Reported in a secondary source with limited study details.
Acute Mammalian Toxicity		LOW: Based on acute oral and dermal LD ₅₀ values of >2000 mg/kg and the inhalation LC ₅₀ value of >20 mg/L.		
Acute Lethality	Oral	Rat oral LD ₅₀ >5,000 mg/kg	IUCLID, 2000	Reported in a secondary source; limited study details provided.
		Rat oral LD ₅₀ >7,500 mg/kg	NIEHS 1999; EPA, 2008a	Reported in a secondary source; some study details provided.
	Dermal	Rabbit dermal LD ₅₀ >2,000 mg/kg	IUCLID, 2000	Reported in a secondary source; some study details provided.
	Inhalation	Rat inhalation 1 hr LC ₅₀ >203 mg/L	NIEHS, 1999; IUCLID, 2000	Reported in a secondary source; limited study details provided; not the preferred 4-hour exposure.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Other Acute Effects		Rat 1-hour inhalation to a dust atmosphere of ethylene bis (tetrabromophthalimide) of $4,500 \pm 3,000 \text{ mg/m}^3$ resulted in dyspnea, and dry, red, brown matter around the muzzle. There were no changes in body weight gain during a 14-day observation period. LOAEL = $4,500 \pm 3,000 \text{ mg/m}^3$	NIEHS, 1999	Reported in a secondary source; limited study details provided; the rats were only exposed to one concentration of the test substance and the mean concentration the rats were exposed to was quite variable, as indicated by a large standard deviation.
Carcinogenicity		MODERATE: Estimated based on lack of experimental carcinogenicity data for this compound or a suitable analog; carcinogenicity cannot be ruled out.		
	OncoLogic Results			Not amenable to available estimation method.
	Carcinogenicity (Rat and Mouse)			No data located.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		LOW: Ethylene bis-tetrabromophthalimide did not cause mutations in bacterial cells or chromosomal aberrations in mammalian cells <i>in vitro</i>.		
	Gene Mutation <i>in vitro</i>	Negative, <i>S. typhimurium</i> TA98, TA100, TA1535, TA1537, TA1538; <i>E. coli</i> WP2uvrA with and without metabolic activation.	NIEHS, 1999; IUCLID, 2000; EPA, 2008a; CCRIS, 2011; NTP, 2011	Reported in secondary sources; sufficient study details provided.
		Negative, <i>S. typhimurium</i> TA98, TA1535, TA1537 with and without metabolic activation.	Zeiger et al., 1985	Reported in a primary source; adequate study details provided.
		Negative, <i>S. typhimurium</i> TA98, TA100, TA1535, TA1537, TA1538; <i>S. cerevisiae</i> D4 with and without metabolic activation.	NIEHS, 1999; IUCLID, 2000; EPA, 2008a	Reported in a secondary source; sufficient study details provided.
	Gene Mutation <i>in vivo</i>			No data located.

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Ethylene Bis-Tetrabromophthalimide CASRN 32588-76-4				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Chromosomal Aberrations <i>in vitro</i>	Negative, Chinese hamster ovary cells with and without metabolic activation.	EPA, 2008a	Reported in a secondary source; sufficient study details provided.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: Based on professional judgment, there is low potential for reproductive toxicity.		
	Reproduction/ Developmental Toxicity Screen	Low potential for reproductive toxicity. (Estimated)	Expert judgment	Estimated based on expert judgment.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		MODERATE: Ethylene bis-tetrabromophthalimide did not cause developmental effects in rats or rabbits following gestational exposure at oral doses as high as 1,000 mg/kg bw-day. However, there is a lack of developmental neurotoxicity data for this compound. A concern for developmental neurotoxicity has been identified for DecaBDE, an analog that shares a key structural feature with ethylene bis-tetrabromophthalimide. Ethylene bis-tetrabromophthalimide also possesses structural features that are not present in DecaBDE and, as a result, the confidence in this assignment is low. Given the absence of developmental neurotoxicity data, potential concerns cannot be ruled out, and an estimated Moderate hazard designation is consistent with the assessment methodology discussed in Chapter 4.		
	Reproduction/ Developmental Toxicity Screen			No data located.

Ethylene Bis-Tetrabromophthalimide CASRN 32588-76-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development	Sprague-Dawley rats (25/group) were administered ethylene bis-tetrabromophthalimide by gavage at 0, 100, 500, or 1,000 mg/kg bw-day on gestation days (GD) 6-15. There were no treatment-related effects on maternal survival, body weight gains, food consumption. There were no treatment-related changes in intrauterine survival and fetal weight, and no changes in the incidence of developmental malformations and variations compared to controls Parental toxicity: NOAEL >1,000 mg/kg bw-day (highest dose tested) Reproductive toxicity: NOAEL >1,000 mg/kg bw-day (highest dose tested)	NIEHS, 1999; IUCLID, 2000; EPA, 2008a	Reported in secondary sources; sufficient study details provided; follows OECD guidelines. The study is in accordance with EPA OPPTS method 870.3700.

Ethylene Bis-Tetrabromophthalimide CASRN 32588-76-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		New Zealand white rabbits (20/group) were administered ethylene bis-tetrabromophthalimide by gavage at 0 or 1,000 mg/kg bw-day on GD 7-19. There were no treatment-related effects on maternal survival, body weight gains, food consumption. There were no treatment-related changes in intrauterine survival and fetal weight, and no changes in the incidence of developmental malformations and variations compared to controls Parental toxicity: NOAEL >1,000 mg/kg bw-day (highest dose tested) Reproductive toxicity: NOAEL >1,000 mg/kg bw-day (highest dose tested)	NIEHS, 1999; IUCLID, 2000; EPA, 2008a	Reported in secondary sources; sufficient study details provided. The study is in accordance with OPPTS method 870.3700; only one dose level tested.
	Postnatal Development/ Developmental Neurotoxicity	Evaluation of locomotor activity in C57BL6/J mice. NOAEL: not established LOAEL: 6 mg/kg-day (based on decreased T4 levels in male mice and effects on locomotor (Estimated by analogy)	EPA, 2008b; Washington DOE, 2008; Professional judgment	Estimated based on analogy to decaBDE which contains similar structural features; study details reported in a secondary source. It should also be noted that ethylene bis-tetrabromophthalimide contains structural features that are not present in decaBDE. Analogs possessing experimental data and containing all of the structural features of ethylene bis-tetrabromophthalimide were not located.

Ethylene Bis-Tetrabromophthalimide CASRN 32588-76-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Single dose gavage in male Sprague Dawley rats; NOAEL: Not established LOAEL: 6.7 mg/kg (Dose-related disruption in habituation [changes in locomotion, rearing, total activity] at both doses). (Estimated by analogy)	EPA, 2008b; Professional judgment	Estimated based on analogy to decaBDE; each dose administered a single time; not a guideline study. Study details reported in a secondary source. It should also be noted that ethylene bis-tetrabromophthalimide contains structural features that are not present in decaBDE. Analogs possessing experimental data and containing all of the structural features of ethylene bis-tetrabromophthalimide were not located.
		NMRI male mice gavaged with decaBDE (99% pure) at 0, 2.22, or 20.1 mg/kg on PNDs3-19 or 0, 1.34, 13.4 or 20.1 mg/kg on PND10. Dose-related disruption in habituation (changes in locomotion, rearing, total activity) at 2, 4, and 6 months following exposure to 20.1 mg/kg on PND3. NOAEL: 2.22 mg/kg LOAEL: 20.1 mg/kg (Estimated by analogy)	European Chemicals Bureau 2002; EPA, 2008b; Professional judgment	Estimated based on analogy to decaBDE; each dose administered a single time; not a guideline study. Study details reported in a secondary source. It should also be noted that ethylene bis-tetrabromophthalimide contains structural features that are not present in decaBDE. Analogs possessing experimental data and containing all of the structural features of ethylene bis-tetrabromophthalimide were not located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Neurotoxicity		LOW: Estimated to have Low potential for neurotoxicity effects estimated based on the absence of structural alerts that have been [experimentally] associated with the neurotoxicity endpoint. There were no experimental data located on this endpoint for ethylene bis-tetrabromophthalimide or an analog.		
	Neurotoxicity Screening Battery (Adult)	Low potential for neurological effects. (Estimated)	Professional judgment	Estimated based on the absence of structural alerts that have been [experimentally] associated with the neurotoxicity endpoint.
Repeated Dose Effects		LOW: A 28- or 90-day dietary exposure to ethylene bis-tetrabromophthalimide in rats at doses as high as 1,000 mg/kg bw-day did not cause adverse effects on growth parameters, clinical chemistry, organ weights and weight ratios, or macro and micro pathology. By analogy to decaBDE and with the potential for bioaccumulation, there is potential for expression of adverse effects in longer term studies.		
		Potential for repeated dose effects (Estimated by analogy and bioaccumulation)	Professional judgment	Estimated based on the high potential for bioaccumulation and by analogy to observations on decaBDE where adverse effects were not present in 90-day studies but were expressed following chronic exposure in a National Toxicology Program study.
		In a 28-day oral (dietary) study in male rats (10/group) fed 0, 0.01, 0.1, or 1% ethylene bis-tetrabromophthalimide, there were no treatment-related changes in growth parameters or food consumption, clinical chemistry, terminal organ weights or weight ratios, or gross and microscopic tissues. NOAEL >1% in diet (>1,000 mg/kg-bw-day) (highest dose tested)	NIEHS, 1999; IUCLID, 2000; EPA, 2008a	Reported in a secondary source; sufficient study details provided. The study does not conform to current guidelines.

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Ethylene Bis-Tetrabromophthalimide CASRN 32588-76-4				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		In a 90-day oral (dietary) study in rats fed 0, 0.01, 0.1, or 1% ethylene bis-tetrabromophthalimide, there were no treatment-related changes in growth parameters or food consumption, clinical chemistry, terminal organ weights or weight ratios, or gross and microscopic tissues; there were unspecified changes in urinalysis. NOAEL >1% in diet (>1,000 mg/kg bw-day) (highest dose tested)	NIEHS 1999; IUCLID 2000; EPA, 2008a	Reported in a secondary source; sufficient study details provided. The study does not conform to current guidelines.
Skin Sensitization		LOW: Estimated to have Low potential for skin sensitization based on expert judgment.		
	Skin Sensitization	Low potential for skin sensitization (Estimated)	Expert judgment	Estimated based on expert judgment.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		VERY LOW: Ethylene bis-tetrabromophthalimide is not an eye irritant in rabbits.		
	Eye Irritation	Not irritating, New Zealand white rabbit	NIEHS, 1999; IUCLID, 2000	Reported in a secondary source; some study details provided.
		Not irritating, albino rabbit	IUCLID, 2000	Reported in a secondary source; limited study details provided.
Dermal Irritation		VERY LOW: Ethylene bis-tetrabromophthalimide is not a skin irritant in rabbits.		
	Dermal Irritation	Not irritating, rabbit; 24-hour occlusive dressing	IUCLID, 2000	Reported in a secondary source; limited study details provided.
		Not irritating, rabbit; 24-hour abraded and nonabraded sites; 24-hour occlusive dressing	NIEHS, 1999; IUCLID, 2000	Reported in secondary sources; sufficient study details provided.
Endocrine Activity		No data located.		
				No data located.
Immunotoxicity		Estimated to have no potential for immunotoxicity based on expert judgment.		
	Immune System Effects	Expected to not have potential for immunotoxicity (Estimated)	Expert judgment	Estimated based on expert judgment.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ECOTOXICITY			
ECOSAR Class	Imides; Amides		
Acute Toxicity	LOW: Estimated data suggest no effects at saturation (NES) for the acute aquatic toxicity endpoints; experimental results are too short a duration to assess the hazard of acute aquatic toxicity, but are consistent with this hazard designation.		
Fish LC₅₀	<i>Oryzias latipes</i> (orange-red killifish) 48-hour LC ₅₀ >500 mg/L (static) (Experimental)	NIEHS, 1999; IUCLID, 2000; EPA, 2008a	48-hour exposure study as opposed to preferred 96-hour study; according to Japanese Ministry of International Trade and Industry (MITI) guidelines.
	Fish 96-hour LC ₅₀ = 0.000084 mg/L (Estimated) ECOSAR: Amides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the structure activity relationship (SAR) limitation for log K _{ow} of 5.0; NES are predicted for these endpoints.
	Fish 96-hour LC ₅₀ = 0.00022 mg/L (Estimated) ECOSAR: Imides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints.
	Fish 96-hour LC ₅₀ = 0.00019 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid LC₅₀	Daphnid 48-hour LC ₅₀ = 0.000274 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Daphnid 48-hour LC ₅₀ = 0.000469 mg/L (Estimated) ECOSAR: Imides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints.
	Daphnid 48-hour LC ₅₀ = 0.000695 mg/L (Estimated) ECOSAR: Amides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints.
Green Algae EC₅₀	Green algae 96-hour EC ₅₀ = 0.003 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae 96-hour EC ₅₀ = 0.02 mg/L (Estimated) ECOSAR: Imides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints.
	Green algae 96-hour EC ₅₀ = 0.014 mg/L (Estimated) ECOSAR: Amides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints.
Chronic Aquatic Toxicity	LOW: Estimated data suggest NES for chronic aquatic toxicity endpoints.		
Fish ChV	Fish 30-day ChV = 0.000000494 mg/L (Estimated) ECOSAR: Amides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.
	Fish 30-day ChV = 0.0000196 mg/L (Estimated) ECOSAR: Imides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.
	Fish 30-day ChV = 0.0000148 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid ChV	Daphnid ChV = 0.00000917 mg/L (Estimated) ECOSAR: Amides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnid ChV = 0.000115 mg/L (Estimated) ECOSAR: Imides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.
	Daphnid ChV = 0.000101 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae ChV	Green algae ChV = 0.004 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Green algae ChV = 0.008 mg/L (Estimated) ECOSAR: Imides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Green algae ChV = 1.59 mg/L (Estimated) ECOSAR: Amides	ECOSAR version 1.11	NES: The log K _{ow} of 9.8 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.
ENVIRONMENTAL FATE				
Transport		The transport evaluation for ethylene bis-tetrabromophthalimide is based on estimated physical and chemical properties. Based on the Level III fugacity models incorporating the located experimental property data, ethylene bis-tetrabromophthalimide is expected to partition primarily to soil. It is not expected to dissociate at environmentally-relevant pH. Ethylene bis-tetrabromophthalimide is expected to have low mobility in soil based on its estimated K_{oc}. Therefore, leaching of ethylene bis-tetrabromophthalimide through soil to groundwater is not expected to be an important transport mechanism. Estimated volatilization half-lives indicate that it will be non-volatile from surface water. In the atmosphere, ethylene bis-tetrabromophthalimide is expected to exist in the particulate phase, based on its estimated vapor pressure. Particulates will be removed from air by wet or dry deposition.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	EPI; Professional judgment	Cutoff value for nonvolatile compounds.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	EPI; EPA, 2004	Cutoff value for nonmobile compounds.
	Level III Fugacity Model	Air ≤1% Water = 5.4% Soil = 95% Sediment ≤1% (Estimated)	EPI	
Persistence		VERY HIGH: The very high persistence for ethylene bis-tetrabromophthalimide is based on limited experimental data and quantitative structure activity relationship (QSAR) estimates. No degradation observed in activated sludge during a MITI test, indicating it is not biodegradable under the stringent test conditions. Results from biodegradation models provided similar results and indicate that it will be recalcitrant under aerobic conditions. Anaerobic degradation under methanogenic conditions is not considered probable. The atmospheric half-life of ethylene bis-tetrabromophthalimide is estimated to be 3.3 hours, although it is expected to exist primarily in the particulate phase in air. Resistance to most environmental fate processes indicates that ethylene bis-tetrabromophthalimide is expected to be persistent in the environment.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Water	Aerobic Biodegradation	Recalcitrant (Primary and Ultimate Survey Model) (Estimated)	EPI	
	Volatilization Half-life for Model River	>1 year (Estimated)	EPI	
	Volatilization Half-life for Model Lake	>1 year (Estimated)	EPI	
Soil	Aerobic Biodegradation	0% after 28 days MITI test (Measured)	EPA, 2008a	Guideline study reported in a secondary source.
	Anaerobic Biodegradation	Not probable (Anaerobic-methanogenic biodegradation probability model) (Estimated)	EPI	
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	3.3 hours (Estimated)	EPI	
Reactivity	Photolysis			No data located.
	Hydrolysis			No data located.
Environmental Half-life		>180 days (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.
Bioaccumulation		HIGH: The potential for bioaccumulation of ethylene bis-tetrabromophthalimide is high based on the estimated BAF. When a single BCF measurement is available Design for the Environment assessment criteria indicate that estimated BAF values are used in a conservative approach. The BAF estimate is consistent with that anticipated for high MW chemicals with a high degree of bromination.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Fish BCF	<0.3 - <3 depending on the concentration tested; in Japanese carp using OECD Test Guideline 305C (Measured)	Hardy, 2004	Guideline study reported in a secondary source. This study is most appropriately applied to organic chemicals with K _{OW} values of 1.5-6.0; the experimental set up did not include exposure through food.
	BAF	1.7×10 ⁵ (Estimated)	EPI	
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Magnesium Hydroxide

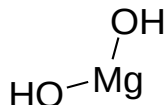
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment. ^R Recalcitrant: Substance is comprised of metallic species that will not degrade, but may change oxidation state or undergo complexation processes under environmental conditions.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Magnesium Hydroxide	1309-42-8	L	L	L	L	L	L	L	L		M	L	L	L	H ^R	L

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Magnesium Hydroxide



CASRN: 1309-42-8

MW: 58.32

MF: MgH₂O₂

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: O[Mg]O

Synonyms: Magnesium hydroxide (Mg(OH)₂); Brucite; Milk of Magnesia; Alcanex NHC 25; Asahi Glass 200-06; Baschem 12; Combustrol 500; Duhor; Duhor N; Ebson RF; FloMag H; FloMag HUS; Hydro-mag MA; Hydrofy G 1.5; Hydrofy G 2.5; Hydrofy N; Kisuma 4AF; Kisuma 5; Kisuma 5A; Kisuma 5B; Kisuma 5B-N; Kisuma 5BG; Kisuma 5E; Kisuma 78; Kisuma S 4; Kyowamag F; Lylcal 96 HSE; Mag Chem MH 10; Magnesia hydrate; MagneClear 58; Magnesia magma; Magnesiamaito; Magnesium dihydroxide; Magnesium hydroxide gel; Magnesium(II) hydroxide; Magnifin H 10; Magox; Marinco H; Marinco H 1241; Martinal VPF 8812; Milmag; Mint-O-Mag; Nermalite; Oxaine M; Phillips Magnesia Tablets; Phillips Milk of Magnesia Liquid; Reachim; Star 200; Versamag

Chemical considerations: This alternative is an inorganic compound. In the absence of experimental data, professional judgment using chemical class and structural considerations were used to complete this hazard profile.

Polymeric: No

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: Not applicable

Analog: No analogs; Mg²⁺ ions are expected to form when Mg(OH)₂ and other magnesium containing compounds dissociate in aqueous conditions. Studies included in this assessment include other sources of Mg²⁺ like MgCl₂.

Endpoint(s) using analog values: Not applicable

Analog Structure: Not applicable

Structural Alerts: None

Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).

Hazard and Risk Assessments: Risk assessment completed for magnesium hydroxide by the National Academy of Sciences in 2000 (NAS, 2000).

Magnesium Hydroxide CASRN 1309-42-8			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	Decomposes at 350 (Measured)	Hodgman, 1959; Lewis, 1997; Lewis, 2000	MgO and H ₂ O are decomposition products.
	Decomposes at 380 (Measured)	IUCLID, 2000	
	350 (Measured)	Lide, 2000; Aldrich, 2006	
Boiling Point (°C)	Will decompose before boiling (Measured)	IUCLID, 2000	Decomposition occurs upon melting as described in additional sources above.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; EPA, 1999	Cutoff value for nonvolatile compounds according to HPV assessment guidance. This inorganic compound is not amenable to available estimation methods.
Water Solubility (mg/L)	1.78 at 20°C, pH 8.3 (Measured) According to Organisation of Economic Cooperation and Development (OECD) 105 column elution method	ECHA, 2013	Guideline study; results are in agreement with other experimental values.
	9 at 18°C (Measured)	Hodgman, 1959; IUCLID, 2000	Measured values, which span a relatively narrow range, are consistently reported in numerous sources.
	1 at 20°C (Measured)	IUCLID, 2000	
	6 at 20°C (Measured)	IUCLID, 2000	
	<8 at 20°C (Measured)	IUCLID, 2000	
	40 at 100°C (Measured)	Hodgman, 1959	Value obtained at an elevated temperature.
Log K_{ow}			No data located; inorganic compounds are outside the estimation domain of EPI.
Flammability (Flash Point)	Not flammable (Estimated)	IUCLID, 2000	Adequate.
Explosivity	Not explosive (Estimated)	IUCLID, 2000	Adequate.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Pyrolysis		Not applicable (Estimated)	Professional judgment	Inorganic compounds do not undergo pyrolysis.
pH		9.5-10.5 (Measured)	O’Neil et al., 2011	Adequate.
		pH of a saturated solution in water was 8.3 (Measured)	ECHA, 2013	Reported in a secondary source, determined from a water solubility study.
pK _a				No data located; inorganic compounds are outside the estimation domain of the SPARC model.
HUMAN HEALTH EFFECTS				
Toxicokinetics		Some magnesium hydroxide is absorbed following ingestion and is excreted primarily in urine.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	The magnesium ion is poorly absorbed; when taken orally, only 5-15% of the magnesium from a dose of magnesium hydroxide is absorbed and this magnesium is readily excreted in the urine, if kidney function is normal.	IUCLID, 2000	Reported in a secondary source, limited study details provided.
Acute Mammalian Toxicity		LOW: Acute lethality values suggest that magnesium hydroxide has Low hazard for acute toxicity for oral exposure. There were no adequate data located regarding acute dermal and inhalation exposure.		
Acute Lethality	Oral	Rat oral LD ₅₀ = 8,500 mg/kg-bw	Lewis, 2000	Reported in a secondary source, limited study details provided.
		Mouse oral LD ₅₀ = 8,500 mg/kg-bw	Lewis, 2000	Reported in a secondary source, limited study details provided.
		Human infant oral TD _{Lo} (behavioral) = 2,747 mg/kg	Lewis, 2000	Reported in a secondary source, limited study details provided.
		Probable human oral lethal dose = 5-15 g/kg-bw	HSDB, 2013	Reported in a secondary source, limited study details provided.
	Dermal			No data located.
	Inhalation	Rat inhalation LC ₅₀ >2.1 mg/L	ECHA, 2013	Reported in a secondary source. There was no mortality at the highest dose tested (2.1 mg/L).

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Carcinogenicity		LOW: Experimental studies indicate that magnesium hydroxide has low hazard for carcinogenicity.		
	OncoLogic Results			Structure could not be evaluated by OncoLogic.
	Carcinogenicity (Rat and Mouse)	5-week, repeated-dose/carcinogenicity study, oral (diet), rat; Decreased number of carcinogen-induced DNA synthesis in the large bowel epithelial cells. NOAEL >2,000 ppm (approximately 100 mg/kg/day, highest dose tested)	BIBRA, 1993	Reported in a secondary source, limited study details provided.
	Combined Chronic Toxicity/ Carcinogenicity	96-week chronic toxicity/carcinogenicity study on MgCl ₂ , oral, mouse; no significant differences in tumor incidence between treated and control animals except for dose-related decrease in the incidence of hepatocellular carcinomas in males.	Kurata et al., 1989	Sufficient study details reported in a primary source.
		227-day, chronic toxicity/ carcinogenicity study, oral (diet), rat; decreased number of colon tumors in rats pretreated with a known colon carcinogen. NOAEL >50 mg/kg/day (highest dose tested)	BIBRA, 1993	Reported in a secondary source, limited study details provided.
		16-week carcinogenicity study, oral (diet), rat; inhibitory effects on colon carcinogenesis, carcinogen-induced expression of <i>c-myc</i> proto-oncogene and cell proliferation. NOAEL = 0.2% in diet (highest concentration tested)	Wang et al., 1993	Sufficient study details reported in a primary source.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Inhalation exposure of male rats to short (4.9 x 0.31 mm) or long (12 x 0.44 mm) MgSO ₄ /5Mg(OH) ₂ 3H ₂ O filaments for 6 hour/day, 5 day/week for up to 1 year did not increase the incidence of any tumor types in animals sacrificed 1 day or 1 year after cessation of exposure.	NAS, 2000	Reported in a secondary source, limited study details provided.
Genotoxicity		LOW: Experimental studies indicate that magnesium hydroxide is not mutagenic to bacteria or mammalian cells <i>in vitro</i> and does not cause chromosomal aberrations in human lymphocytes <i>in vitro</i>.		
	Gene Mutation <i>in vitro</i>	Negative, Ames Assay in <i>Salmonella</i> and <i>Escherichia coli</i>	BIBRA, 1993	Reported in a secondary source, limited study details provided. Only 3 strains of <i>Salmonella</i> were tested; current regulatory guidelines suggest that at least 4 strains be used in Ames tests.
		Negative; mouse lymphoma assay, L5178Y cells; with and without metabolic activation	ECHA, 2013	Reported in a secondary source.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative; did not induce chromosomal aberrations in human lymphocytes; with and without metabolic activation	ECHA, 2013	Reported in a secondary source.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		LOW: There were no reproductive effects observed in rats in a repeated dose toxicity study with the reproduction/developmental toxicity screen at doses of magnesium hydroxide as high as 1,000 mg/kg-day. In addition, magnesium hydroxide is expected to have low hazard for reproductive effects based on a nonstandard experimental study indicating magnesium chloride produces no adverse effects on reproductive performance or outcomes at levels up to 96 mg/kg/day of Mg²⁺ ion.		
	Reproduction/ Developmental Toxicity Screen	10-day (gestation days (GDs) 6-15) reproductive/developmental study on MgCl ₂ , oral, rat; no maternal or reproductive effects. NOAEL >96 mg/kg/day for Mg ²⁺ ion (highest dose tested) LOAEL: Not established	NAS, 2000	Reported in a secondary source, limited study details provided.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Repeated dose toxicity study with the reproduction/developmental toxicity screen; rat, oral (gavage), 0, 110, 330, 1,000 mg/kg-day magnesium hydroxide. Males exposed for 29 days: 2 weeks prior to mating, during mating and up to termination; females exposed for 41-45 days: 2 weeks pre-mating, during mating, post coitum, and 4 days of lactation. There were no reproductive effects observed in any dose group. NOAEL >1,000 mg/kg-day LOAEL: Not established	ECHA, 2013	Reported in a secondary source. Study conducted according to OECD 422.
	Reproduction and Fertility Effects			No data located.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Developmental Effects		LOW: Magnesium hydroxide is expected to have low hazard for developmental effects based on a nonstandard experimental study indicating magnesium chloride produces no adverse effects on developmental outcomes at levels up to 96 mg/kg/day of Mg²⁺ ion and an experimental study from a secondary source showing no effect on human newborns. In addition, there were no developmental effects observed in rats in a repeated dose toxicity study with the reproduction/developmental toxicity screen at doses as high as 1,000 mg/kg-day.		
	Reproduction/ Developmental Toxicity Screen	10-day (GD 6-15) reproductive/developmental study on MgCl ₂ , oral, rat; no maternal or reproductive effects. NOAEL >96 mg/kg/day for Mg ²⁺ ion (highest dose tested) LOAEL: Not established	NAS, 2000	Reported in a secondary source, limited study details provided.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Repeated-dose/developmental study (fetal exposure at unspecified dose levels during 3 rd trimester), 27 hypertensive women treated with magnesium hydroxide, no effect on newborns except slightly increased body weight and hypermagnesemia. Cord serum Mg levels reported to be 70-100% of maternal levels after treatment (potentially causing neurological depression in neonate, characterized by respiratory depression, muscle weakness, decreased reflexes). Prolonged magnesium treatment during pregnancy may be associated with maternal and fetal hypocalcemia and adverse effects on fetal bone mineralization.	HSDB, 2013	Reported in a secondary source, limited study details provided. Maternal treatment doses not specified.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Repeated dose toxicity study with the reproduction/developmental toxicity screen; rat, oral (gavage), 0, 110, 330, 1,000 mg/kg-day. Males exposed for 29 days: 2 weeks prior to mating, during mating and up to termination; females exposed for 41-45 days: 2 weeks pre-mating, during mating, post coitum, and 4 days of lactation. There were no developmental effects observed in any dose group. NOAEL >1,000 mg/kg-day LOAEL = Not established	ECHA, 2013	Reported in a secondary source. Study conducted according to OECD 422.
	Prenatal Development			No data located.
	Postnatal Development			No data located.
Neurotoxicity		LOW: Magnesium hydroxide is expected to be of low hazard for neurotoxicity based on expert judgment.		
	Neurotoxicity Screening Battery (Adult)	Low potential for neurotoxicity. (Estimated)	Expert judgment	Estimated based on expert judgment.

Magnesium Hydroxide CASRN 1309-42-8			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects	LOW: Experimental studies indicate magnesium ions produce no adverse systemic effects in rats or mice at magnesium levels $\geq 1,000$ mg/kg/day of magnesium hydroxide.		
	96-week repeated-dose study for MgCl_2, oral (0, 0.5, 2% in the diet), mouse; decreased body weight gain, increased food/water consumption and increased relative brain, heart and kidney weights in high dose (2%) females, no effects in males. Female: NOAEL = 87 mg/kg-day for Mg^{2+} ion LOAEL = 470 mg/kg/day for Mg^{2+} ion Male: NOAEL = 336 mg/kg-day for Mg^{2+} ion (highest dose tested) LOAEL: Not established	Kurata et al., 1989	Adequate, primary source.
	90-day repeated-dose study for MgCl_2, oral, mouse (M: 73, 146, 322, 650, 1,368 mg/kg-day; F: 92, 190, 391, 817, 1,660 mg/kg-day); decreased body weight gain in males and females at highest doses tested (1,660 mg/kg-day); renal tubular vacuolation in males administered 650 mg/kg-day for Mg^{2+} ion. Female: NOAEL = 817 mg/kg/day for Mg^{2+} ion LOAEL = 1,660 mg/kg/day for Mg^{2+} ion Male: NOAEL = 322 mg/kg/day for Mg^{2+} ion LOAEL = 650 mg/kg/day for Mg^{2+} ion	NAS, 2000	Reported in a secondary source, no study details provided.

Magnesium Hydroxide CASRN 1309-42-8			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	90-day repeated-dose study for MgCl_2 , oral, mouse; decreased body weight gain, renal tubular vacuolation in males. Female: NOAEL = 587 mg/kg/day for Mg^{2+} ion Male: LOAEL = 840 mg/kg-day NOAEL = 420 mg/kg/day for Mg^{2+} ion	NAS, 2000	Reported in a secondary source, no study details provided.
	32-week repeated-dose study, diet, rat; no effects on body weight or liver weight. NOAEL >1,000 ppm (approximately 50 mg/kg/day)	BIBRA, 1993	Reported in a secondary source, no study details provided.
	Inhalation exposure of male rats to short (4.9 x 0.31 mm) or long (12 x 0.44 mm) $\text{MgSO}_4/5\text{Mg}(\text{OH})_2 \cdot 3\text{H}_2\text{O}$ filaments for 6 hour/day, 5 day/week for up to 1 year (concentration not specified) exhibited a slight increase in the incidence of pulmonary lesions 1 year after cessation of exposure. Histopathological examination revealed a slight increase in segmental calcification of the pulmonary artery and thickening of the lung pleura in rats exposed to both short and long filaments for 4 weeks or 1 year. There were no effects on survival or body, lung, liver, kidney and spleen weights of animals sacrificed 1 day or 1 year following a 1-year exposure period.	NAS, 2000	Reported in a secondary source, no study details provided.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		4-week repeated-dose study, oral, human; caused diarrhea, abdominal discomfort, and increased serum magnesium levels. LOAEL = 400 mg/day	BIBRA, 1993	Reported in a secondary source, no study details provided.
		Repeated dose toxicity study with the reproduction/developmental toxicity screen; rat, oral (gavage), 0, 110, 330, 1,000 mg/kg-day. Males exposed for 29 days: 2 weeks prior to mating, during mating and up to termination; females exposed for 41-45 days: 2 weeks pre-mating, during mating, post coitum, and 4 days of lactation. There were no toxicologically relevant changes in any of the parental parameters examined. NOAEL >1,000 mg/kg-day LOAEL: Not established	ECHA, 2013	Reported in a secondary source. Study conducted according to OECD 422.
		Human systemic effects: chlorine level changes, coma, somnolence.	Lewis, 2000	Reported in a secondary source, no study details provided.
		Repeated use in humans may rarely cause rectal stones composed of magnesium carbonate and magnesium hydroxide.	IUCLID, 2000	Reported in a secondary source, no study details provided.
	Immune System Effects	Low potential for immunotoxicity. (Estimated)	Expert judgment	Estimated based on expert judgment.
Skin Sensitization		LOW: Magnesium hydroxide is not estimated to cause skin sensitization based on professional judgment.		
	Skin Sensitization	Does not cause skin sensitization (Estimated)	Professional judgment	Estimated by professional judgment.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Eye Irritation		MODERATE: Based on irritation and damage to the corneal epithelium in rabbits that cleared within 2-3 days.		
	Eye Irritation	Moderately irritating to rabbit eyes.	IUCLID, 2000	Reported in a secondary source, limited study details provided.
		Administration of milk of magnesia twice a day for 3-4 days caused damage to corneal epithelium of rabbit eyes; however, effects disappeared within 2-3 days.	HSDB, 2013	Reported in a secondary source, limited study details provided. Milk of magnesia is a mixture containing magnesium hydroxide and inactive ingredients.
Dermal Irritation		LOW: An experimental study indicates that magnesium hydroxide is not an irritant to rabbit skin.		
	Dermal Irritation	Moderate potential for dermal irritation based on experimental aqueous pH values. (Estimated)	Expert judgment	Estimated based on expert judgment.
		Causes skin irritation	Fisher Scientific, 2007	Reported in a secondary source, no experimental study was identified or study details provided.
		Not corrosive in an <i>in vitro</i> human skin corrosion test.	ECHA, 2013	Reported in a secondary source. Study conducted according to OECD guideline 431.
		Not irritating in an <i>in vitro</i> skin irritation test.	ECHA, 2013	Reported in a secondary source. <i>In vitro</i> skin irritation: reconstructed human epidermis model test.
		Not irritating, rabbits	Submitted confidential study	Reported in a submitted confidential study.
Endocrine Activity		No data located.		
				No data located.
Immunotoxicity		Magnesium hydroxide is expected to have low potential for immunotoxicity based on expert judgment.		
	Immune System Effects	Low potential for immunotoxicity (Estimated)	Expert judgment	Estimated based on expert judgment.

Magnesium Hydroxide CASRN 1309-42-8			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ECOTOXICITY			
ECOSAR Class	Not applicable		
Acute Toxicity	LOW: Estimated LC₅₀ values for all of the standard toxicity test organisms are greater than 100 mg/L. Experimental LC₅₀ values are much greater than the anticipated water solubility, suggesting no effects at saturation (NES).		
Fish LC₅₀	96-hour LC ₅₀ = 1,110 mg/L (Estimated)	Mount et al., 1997	Estimated from the measured LC ₅₀ s for MgCl ₂ and MgSO ₄ , modified by a MW adjustment for Mg(OH) ₂ ; expected to display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
	<i>Pimephalis promelas</i> 96-hour LC ₅₀ = 511 mg/L; static conditions (Experimental)	ECHA, 2013	Reported in a secondary source. Test material diluted to 61% in aqueous suspension.
	<i>Onchorinchus mykiss</i> 96-hour LC ₅₀ = 775.8 mg/L; static conditions (Experimental)	ECHA, 2013	Reported in a secondary source. Test material diluted to 61% in aqueous suspension.
Daphnid LC₅₀	48-hour LC ₅₀ = 648 mg/L (Estimated)	Biesinger and Christensen, 1972; Mount et al., 1997	Estimated from the measured LC ₅₀ s for MgCl ₂ and MgSO ₄ , modified by a MW adjustment for Mg(OH) ₂ ; expected to display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
	<i>Daphnia magna</i> 48-hour LC ₅₀ = 284.76 mg/L; static conditions (Experimental)	ECHA, 2013	Reported in a secondary source. Test material diluted to 61% in aqueous suspension.
Other Freshwater Invertebrate LC₅₀	<i>Gammarus lacustris</i> LC ₅₀ = 64.7 mg/L (Experimental)	O'Connell et al., 2004	Reported in a secondary source, study details and test conditions were not provided. Not a standard test species.

Magnesium Hydroxide CASRN 1309-42-8			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Green Algae EC ₅₀	96-hour EC ₅₀ = 2,111 mg/L (Estimated)	Professional judgment	Estimated using an acute to chronic ratio (ACR) of 4; expected to display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
	<i>Scenedesmus subspicatus</i> and <i>Selenastrum capricornutum</i> 72-hour EC ₅₀ >100 mg/L (for growth and biomass) (Experimental)	ECHA, 2013	Reported in a secondary source.
Chronic Aquatic Toxicity	LOW: Estimated ChVs are all >10 mg/L and exceed the anticipated water solubility, suggesting NES.		
Fish ChV	403 mg/L (Estimated)	Professional judgment	Estimated using an ACR of 3:3; expected to display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
Daphnid ChV	197 mg/L (Estimated)	Suter, 1996	Estimated from the measured ChV for Mg ²⁺ ion, modified by a MW adjustment for Mg(OH) ₂ ; expected to display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
Green Algae ChV	528 mg/L (Estimated)	ECOTOX	Estimated from the measured NOEC and LOEC for MgSO ₄ , modified by a MW adjustment for Mg(OH) ₂ ; expected to display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The low water solubility, the estimated vapor pressure of $<1 \times 10^{-8}$ mm Hg, estimated K_{oc} of $>30,000$ and estimated Henry's Law Constant of $<1 \times 10^{-8}$ atm-m ³ /mole indicate that magnesium hydroxide will be relatively immobile in the environment. Magnesium hydroxide is a mineral occurring naturally in the environment.		
	Henry's Law Constant (atm-m ³ /mole)	$<10^{-8}$ (Estimated)	Professional judgment	Cutoff value for nonvolatile compounds. This inorganic compound is not amenable to available estimation methods.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	$>30,000$ (Estimated)	Professional judgment; EPA, 2004	Cutoff value for nonmobile compounds.
	Level III Fugacity Model			Not all input parameters for this model were available to run the estimation software (EPI).
Persistence		HIGH: As an inorganic compound, magnesium hydroxide is not expected to biodegrade, oxidize in air, or undergo hydrolysis under environmental conditions. Magnesium hydroxide does not absorb light at environmentally relevant wavelengths and is not expected to photolyze. Magnesium hydroxide is recalcitrant and it is expected to be found in the environment >180 days after release. As a naturally occurring compound, it may participate in natural cycles and form complexes in environmental waters.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	Substance is or contains inorganic elements, such as metal ions or oxides, that are expected to be found in the environment >180 days after release.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	This inorganic compound is not amenable to available estimation methods.

Magnesium Hydroxide CASRN 1309-42-8				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Anaerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	This inorganic compound is not amenable to available estimation methods.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	>1 year (Estimated)	Professional judgment	Substance does not contain functional groups amenable to atmospheric degradation processes.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Professional judgment	Magnesium hydroxide does not absorb UV light at environmentally relevant wavelengths and is not expected to undergo photolysis.
	Hydrolysis	Not a significant fate process (Estimated)	Professional judgment	Substance does not contain functional groups amenable to hydrolysis.
Environmental Half-life				Not all input parameters for this model were available to run the estimation software (EPI).
Bioaccumulation		LOW: Magnesium hydroxide is not expected to bioaccumulate based on professional judgment.		
	Fish BCF	<100 (Estimated)	Professional judgment	This inorganic compound is not amenable to available estimation methods.
	BAF	<100 (Estimated)	Professional judgment	This inorganic compound is not amenable to available estimation methods.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		Magnesium hydroxide is a mineral that occurs naturally in the environment.		
Ecological Biomonitoring		No data located.		

Magnesium Hydroxide CASRN 1309-42-8			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Human Biomonitoring	This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Melamine Cyanurate

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

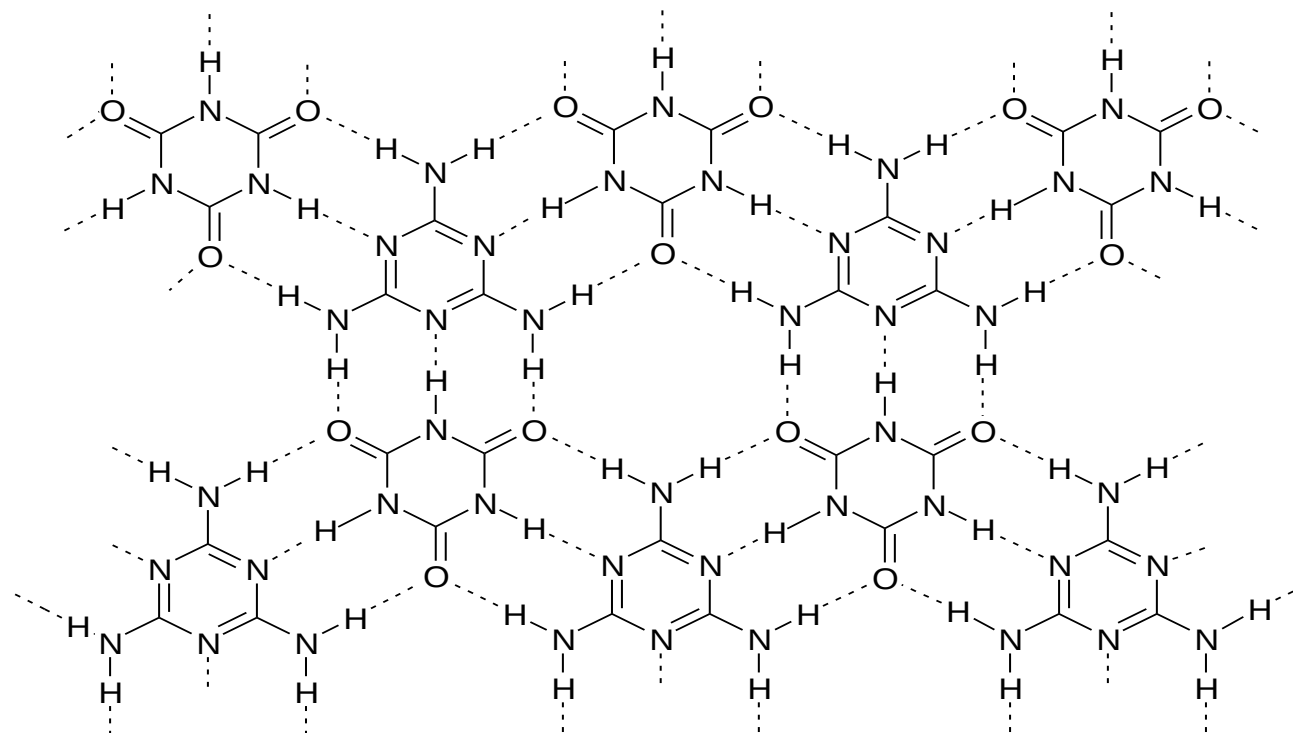
^s Based on analogy to experimental data for a structurally similar compound.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Melamine Cyanurate ¹	37640-57-6	<i>L</i>	<i>M</i>	<i>M</i>	<i>M</i> ^s	<i>M</i> ^s	<i>L</i>	<i>H</i>	<i>L</i>		<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>VH</i>	<i>L</i>

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

¹ Hazard designations are based upon the component of the salt with the highest hazard designation, including the corresponding free acid or base.

Melamine Cyanurate



CASRN: 37640-57-6

MW: 255 (Empirical)

MF: $C_3H_6N_6 \cdot C_3H_3N_3O_3$

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: n1c(N)nc(N)nc1N(H)(H)(H)N2C(=O)NC(=O)NC2=O (Empirical)

Synonyms: 1,3,5-Triazine-2,4,6(1H,3H,5H)-trione, compd. with 1,3,5-triazine-2,4,6-triamine (1:1); 1,3,5-triazine-2,4,6-trione - 1,3,5-triazine-2,4,6-triamine (1:1); Melapur MC XL; Melamine isocyanurate

Chemical Considerations: This alternative is an organic salt of melamine (CASRN 108-78-1) and cyanuric acid (CASRN 108-80-5) organized in a well ordered crystalline complex, with extensive intramolecular hydrogen bonding. The abundance of complimentary hydrogen bonds effectively link melamine and cyanuric acid into stable lattice chains. The potential for dissolution of these chains are dependent on pH. The simplest 1:1 melamine cyanurate complex has an empirical MW of 255; although higher MW networks are expected because the integrated melamine cyanurate complex has a higher degree of stabilization than isolated components (Perdigão et al., 2006). This assessment will consider the worst case hazard concerns which may include those from the dissolution of melamine and cyanuric acid from the complex.	
Polymeric: No Oligomers: Not applicable	
Metabolites, Degradates and Transformation Products: Melamine (CASRN 108-78-1); cyanuric acid (CASRN 108-80-5)	
Analogs: Confidential analog, nitrogen heterocycles Endpoint(s) using analog values: Reproductive effects; developmental effects	Analog Structures: Confidential; nitrogen heterocycles is a class of cyclic compounds that have nitrogen atoms and at least one other element as members of its ring.
Structural Alerts: Aromatic amine (EPA, 2011)	
Risk Phrases: Xn- harmful; R48/22 - harmful: danger of serious damage to health by prolonged exposure if swallowed (ECHA, 2011a).	
Hazard and Risk Assessments: None identified	

Melamine Cyanurate CASRN 37640-57-6			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)			No data located.
Boiling Point (°C)	>350 decomposes (Measured)	Leisewitz et al., 2001; ECHA, 2011a	Based on the reported thermal stability value.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; EPA, 1999	Cutoff value for nonvolatile compounds according to HPV assessment guidance; based on the ionic nature of the material.
Water Solubility (mg/L)	Approximately 27 at 20°C (Organisation of Economic Cooperation and Development (OECD) 105) (Measured)	ECHA, 2011a	Guideline study.
	10 at 20°C (Measured)	ECHA, 2011a	Nonguideline studies at neutral pH that substantiate the limited solubility anticipated under neutral conditions.
	1 at 20°C (Measured)	ECHA, 2011a	
	2 at 25°C (Measured)	Ciba, 2001	
	1.5 at 37°C (Measured)	ECHA, 2011a	Non-quantitative supporting information that describes the behavior of the compound in water.
	Under neutral conditions melamine and cyanuric acid form a stable and insoluble hydrogen-bonded network; the network is destabilized at pH extremes (Measured)	Rovner, 2008	
	Very insoluble in water (Measured)	Crews, 2006	
Log K _{ow}	Not soluble at room temperature (Measured)	ICL Industrial Products (IP), 2011	Inadequate; qualitative, nonspecific value.
	Melamine Cyanurate: <0 (Estimated) Melamine: -1.37 (Measured) Cyanuric Acid: -0.47 (Measured)	ECHA, 2011a; Hansch, 1995; Kaune et al., 1998; Pakalin et al., 2007	Inadequate, based on experimental water solubility data. These values are not applicable for the melamine cyanurate complex.

Melamine Cyanurate CASRN 37640-57-6				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Flammability (Flash Point)		Self-ignition temperature: >400°C (Measured)	ECHA, 2011a	Adequate.
Explosivity		Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis				No data located.
pH	5-6 (Measured)		ECHA, 2011a	Inadequate, these data are not consistent with the well conducted water solubility studies; purity of test material not reported.
	5.5 (Measured)		Ciba, 2001	
pK _a		Melamine: 5 (Measured) Cyanuric Acid: 6.88, 11.4, 13.5 (Measured)	ECHA, 2011a	Inadequate, these data values are not applicable for the melamine cyanurate complex.
HUMAN HEALTH EFFECTS				
Toxicokinetics		The melamine cyanurate complex is expected to have limited bioavailability for dermal and inhalation routes of exposure due to its low water solubility under neutral conditions. It is expected to not be absorbed through skin and to have poor absorption through the lung and gastrointestinal tract. The dissolution of melamine cyanurate and the solubility and precipitation of melamine and cyanuric acid appear to be pH-dependent indicating that ingestion of this compound may enhance bioavailability. Melamine is distributed to the stomach, small intestine, cecum, and large intestine, and found in blood and urine of rats. Cyanuric acid distributes rapidly following oral administration with the highest concentrations found in blood, liver and kidney. The elimination phase half-life for melamine is approximately 3 hours. Cyanuric acid is quickly excreted primarily in the urine as the unchanged compound.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Melamine cyanurate: Not absorbed through skin; poor absorption through lung and gastrointestinal tract (Estimated)	Professional judgment.	Estimated based on limited bioavailability and not expected to be readily absorbed; however, ingested melamine cyanurate could be dissociated to form melamine and cyanuric acid in the low pH environment found in the stomach.

Melamine Cyanurate CASRN 37640-57-6

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine and cyanuric acid co-exposure: The solubility of melamine and cyanuric acid in urine was higher than in water suggesting a pH-dependent effect. The lowest solubility was at a pH of 5–5.5; Solubility in human urine was in the range of 250 mg/L at pH 3 and 8. The solubility limits for melamine and cyanurate increased with increasing pH over the range of 5-8.3 and solubility at pH 5 was 30 mg/L in rats. There is a pH-dependent precipitation of melamine and cyanuric acid in rat and human urine. No difference in crystal formation was observed at the 1- or 24-hour time point.	ECHA, 2011a	Study details reported in a secondary source.
		Melamine and cyanuric acid co-exposure: Melamine and cyanuric acid orally (gavage) administered separately formed crystals of melamine cyanurate in the kidneys of rats. There was decreased creatinine clearance, increased in serum creatinine and Blood Urea Nitrogen (BUN) ratio; increased absolute and relative kidney weight.	ECHA, 2011a	Sufficient details reported in a secondary source.
		Melamine: The elimination phase half-life calculated from plasma data was 2.7 hours, and the urinary half-life was 3.0 hours. The renal clearance was determined to be 2.5 mL/min.	Mast et al., 1983	Adequate, nonguideline study.
		Melamine: Distributed to stomach, small intestine, cecum, and large intestine, and found in blood and urine of rats.	ECHA, 2011b	Study details reported in a secondary source.

Melamine Cyanurate CASRN 37640-57-6

Melamine Cyanurate CASRN 37640-57-6				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Cyanuric acid: There was 98% recovery of ingested cyanuric acid in urine of 2 volunteers; elimination half-life estimated to be 2.2–3.5 hours; consistent with the one-compartment open model with first order input and elimination; cyanuric acid is excreted rapidly and nearly completely after ingestion.	OECD SIDS, 1999b	Study details reported in a secondary source.
		Cyanuric acid: Distributes rapidly following oral administration to rats; highest concentrations found in blood, liver and kidney with maximum concentrations 30 minutes after dosing; excreted primarily in urine as unchanged substance; poor dermal absorption.	ECHA, 2011b	Sufficient details reported in a secondary source; test substance identified as 2,4,6-isocyanuric acid.
Acute Mammalian Toxicity		LOW: Estimated based on measured acute oral, dermal, and inhalation toxicity values for the dissolution products melamine and cyanuric acid. The melamine cyanurate complex is also estimated to have limited bioavailability and water solubility that is consistent with a low hazard for dermal and inhalation routes of exposure.		
Acute Lethality	Oral	Melamine: Rat LD ₅₀ = 3,161 mg/kg b.w. (male), 3,828 mg/kg (female)	NTP, 1983; Melnick et al., 1984	Sufficient study details reported.
		Melamine: Mouse LD ₅₀ = 3,296 mg/kg (male), 7,014 mg/kg (female)	NTP, 1983; Melnick et al., 1984	Sufficient study details reported.
		Melamine: Mouse LD ₅₀ = 4,550 mg/kg	American Cyanamid Company, 1955; May, 1979; Trochimowicz et al., 2001	Sufficient study details were not available. Reported in secondary sources.
		Melamine: Rat LD ₅₀ = 3,160 mg/kg (male), 3,850 mg/kg (female)	Trochimowicz et al., 2001	Sufficient study details were not reported.
		Melamine: Rat LD ₅₀ >6,400 mg/kg	BASF, 1969 (as described in IUCLID, 2000 and OECD SIDS, 1999a)	Sufficient study details were not available.
		Melamine: LD ₅₀ ≈ 4,800 mg/kg	Hoechst, 1963 (as described in IUCLID, 2000)	Sufficient study details were not available.

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Melamine Cyanurate CASRN 37640-57-6				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Cyanuric acid: Rat LD ₅₀ >5,000 mg/kg	ECHA, 2011b	Sufficient study details reported in a secondary source; OECD guideline 420.
		Cyanuric acid: Rat LD ₅₀ = 7,700 mg/kg	OECD SIDS, 1999b	Reported in a secondary source with limited study details provided; purity unknown.
		Cyanuric acid: Mouse LD ₅₀ = 3,400 mg/kg	OECD SIDS, 1999b	Reported in a secondary source with limited study details provided; purity unknown.
		Cyanuric acid: Rabbit LD ₅₀ >10 mg/kg	OECD SIDS, 1999b	Reported in a secondary source with limited study details provided; purity unknown.
	Dermal	Melamine cyanurate: Estimated to have limited bioavailability and therefore has low potential for hazard for the dermal route of exposure (Estimated)	Professional judgment	Based on physical chemical properties including limited bioavailability and low water solubility.
		Melamine: Rabbit LD ₅₀ >1,000 mg/kg	Unknown, 1990	Sufficient study details were not available.
		Cyanuric acid: Rabbit LD ₅₀ >7,940 mg/kg	OECD SIDS, 1999b	Reported in a secondary source with limited study details provided; purity unknown.
		Cyanuric acid: Rabbit LD ₅₀ >5,000 mg/kg	ECHA, 2011b	Sufficient study details reported in a secondary source; OECD guideline 402.
	Inhalation	Melamine cyanurate: Estimated to have limited bioavailability and therefore has low potential for hazard for the inhalation route of exposure (Estimated)	Professional judgment	Based on physical chemical properties including limited bioavailability and low water solubility.
		Melamine: Rat LC ₅₀ = 3.248 mg/L	Ubaidullajev, 1993	The study details, if present, were not translated into English.
		Cyanuric acid: Rat LC ₅₀ >5.25 mg/L	ECHA, 2011b	Sufficient study details reported in a secondary source; OECD guideline 403.

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Melamine Cyanurate CASRN 37640-57-6				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Carcinogenicity		MODERATE: Estimated based on the dissolution product melamine. There is evidence that oral melamine exposure causes carcinogenicity in experimental animals; however, there was no evidence located as to its carcinogenicity to humans. Tumor formation in animals appears to happen in a mechanical nature under conditions in which it produces bladder calculi. Cyanuric acid is not carcinogenic. There were no data located as to the carcinogenic potential of the melamine cyanurate complex. The International Agency for Research on Cancer (IARC) classifies melamine as Group 3: <i>not classifiable as to its carcinogenicity to humans</i> .		
	OncoLogic Results	Melamine: Marginal (Estimated)	OncoLogic, 2008	
	Carcinogenicity (Rat and Mouse)	Melamine: Group 3: melamine is not classifiable as to its carcinogenicity to humans; there is inadequate evidence in humans for the carcinogenicity of melamine, and there is sufficient evidence in experimental animals for the carcinogenicity of melamine under conditions in which it produces bladder calculi.	IARC, 1999	IARC classification statement.
		Melamine: Significant formation of transitional cell carcinomas in the urinary bladder of dosed male rats and significant chronic inflammation in the kidney of dosed female rats were observed following exposure in the feed for up to 103 weeks. Carcinoma formation was significantly correlated with the incidence of bladder stones. A transitional-cell papilloma was observed in the urinary bladder of a single high dose male rat, and compound related lesions were observed in the urinary tract of dosed animals.	NTP, 1983; Huff, 1984; Melnick et al., 1984	Sufficient study details reported.

Melamine Cyanurate CASRN 37640-57-6

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Increased incidence of acute and chronic inflammation and epithelial hyperplasia of the urinary bladder were observed in male mice following oral (feed) exposure for up to 103 weeks. Bladder stones and compound related lesions were observed in the urinary tract of test animals. There was no evidence of bladder tumor development. Melamine was not considered carcinogenic.	NTP, 1983; Huff, 1984; Melnick et al., 1984	Sufficient study details reported.
		Melamine: Melamine-induced proliferative lesions of the rat urinary tract were directly due to the irritant stimulation of calculi, and not to molecular interactions between melamine or its metabolites with the bladder epithelium.	Okumura et al., 1992	Sufficient study details reported.
		Melamine: Water intake, used as an index of urinary output, was increased by NaCl treatment. Calculus formation resulting from melamine administration was suppressed dose-dependently by the simultaneous NaCl treatment. The main constituents of calculi were melamine and uric acid (total contents 61.1–81.2%). The results indicate that melamine-induced proliferative lesions of the urinary tract of rats were directly due to the irritation induced-stimulation of calculi, and not molecular interactions between melamine itself or its metabolites with the bladder epithelium.	Ogasawara et al., 1995	Sufficient study details reported.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: As an initiator, melamine caused no significant increase in papillomas per mouse when compared to controls.	Perrella and Boutwell, 1983	Sufficient study details reported; nonguideline study.
		Melamine: Diffuse papillary hyperplasia of the bladder epithelium and bladder calculi were observed in all melamine treated rats. Elevated spermidine/spermine N1-acetyltransferase activity following melamine treatment was considered to be an indicator of cell proliferation.	Matsui-Yuasa et al., 1992	Sufficient study details reported; nonguideline study.
		Melamine: Decreased antitumor activity was correlated with increasing demethylation; melamine was considered inactive as an antitumor drug.	Rutty and Connors, 1977	Sufficient study details were not available.
		Melamine: In an <i>in vitro</i> cytotoxicity study in cultured ADJ/PC6 plasmacytoma ascites tumor cells the ID ₅₀ was 470 µg/mL after 72 hours of treatment.	Rutty and Abel, 1980	Sufficient study details were not available.
	Combined Chronic Toxicity/ Carcinogenicity	Melamine: No effects were observed in rats fed 1,000 ppm of melamine. Four of the 10 rats fed 10,000 ppm of melamine had bladder stones associated with the development of benign papillomas.	Anonymous, 1958 (as described in EPA, 1992)	Sufficient study details were not available.
		Melamine: Increased incidence of urinary bladder stones (6/20 rats) was noted in the 10,000 ppm dose group, and was associated with an increase in benign papillomata. The NOAEL was determined to be 1,000 ppm (67 mg/kg).	American Cyanamid Company, 1955	Sufficient study details were not available.

Melamine Cyanurate CASRN 37640-57-6

Melamine Cyanurate CASRN 37640-57-6				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Cyanuric acid: Rat, oral (drinking water), 2-year toxicity and oncogenicity study; there was no evidence of treatment-related carcinogenic effects in tissues or organs in any treatment group.	ECHA, 2011b	Sufficient study details reported in a secondary source; EU Method B.33 (combined chronic toxicity/carcinogenicity test); test substance identified as s-triazinetriol, monosodium salt (monosodium cyanurate monohydrate) 99.7% (equivalent to 77.4% cyanuric acid).
		Cyanuric acid: Mouse, oral (drinking water), 2-year toxicity and oncogenicity study; there was no evidence of treatment-related carcinogenic effects in tissues or organs in any treatment group.	ECHA, 2011b	Sufficient study details reported in a secondary source; EU Method B.33 (combined chronic toxicity/carcinogenicity test); test substance identified as monosodium cyanurate monohydrate (equivalent to 77.5% cyanuric acid).
Genotoxicity		MODERATE: Melamine cyanurate is estimated to be a moderate hazard for genotoxicity based on the data for melamine. For melamine, positive results were observed for <i>in vivo</i> chromosome aberration and sister chromatid exchange assays conducted by National Toxicology Program (NTP) in 1988 and 1989. Available <i>in vitro</i> genotoxicity testing was conducted with metabolic activation systems from the liver. NTP suggests this may not account for potential activation from bladder epithelial cells, which is the target organ. Proposed genotoxicity testing using a metabolic activation system from bladder epithelial cells (NTP, 1983) was never conducted (Personal Communication, 2007; 2008). Cyanuric acid does not cause gene mutations or chromosomal aberrations <i>in vitro</i>. There was one study located for melamine cyanurate, which demonstrated negative results for an <i>in vitro</i> chromosomal aberration study.		
	Gene Mutation <i>in vitro</i>	Melamine: Bacterial forward mutation assay: Negative with and without liver activation	Haworth et al., 1983; NCI/NTP, 2007	Sufficient study details reported.
		Melamine: Bacterial forward mutation assay: Negative	Seiler, 1973	Sufficient study details were not available.
		Melamine: Bacterial reverse mutation assay: Negative with and without liver activation	Lusby et al., 1979	Sufficient study details were not available.

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Melamine Cyanurate CASRN 37640-57-6				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Bacterial reverse mutation assay: Negative with and without unspecified metabolic activation	Mast et al., 1982a	Sufficient study details were not available.
		Melamine: <i>In vitro</i> mouse lymphoma test: Negative with and without liver activation	McGregor et al., 1988; NCI/NTP, 2007	Sufficient study details reported.
		Melamine: Chinese hamster ovary (CHO) cells/hypoxanthine-guanine phosphoribosyl-transferase forward mutation assay: Negative with and without liver activation	Mast et al., 1982a	Sufficient study details were not available.
		Cyanuric acid: Negative for mutagenicity to <i>S. typhimurium</i> TA1535, TA1537, TA98, TA100 with and without metabolic activation	OECD SIDS, 1999b	Reported in a secondary source with limited study details provided; purity unknown.
		Cyanuric acid: Negative for bacteriophage Lambda induction in <i>E. coli</i> with and without metabolic activation	OECD SIDS, 1999b	Reported in a secondary source with limited study details provided; purity unknown.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Melamine cyanurate: <i>In vitro</i> chromosomal aberrations test: Negative in Chinese hamster lung fibroblasts (V79) with and without metabolic activation	ECHA, 2011a	OECD guideline 473.
		Melamine: <i>In vitro</i> chromosomal aberrations test: Negative in CHO with and without liver activation	Galloway et al., 1987; NCI/NTP, 2007	Sufficient study details reported.
		Melamine: <i>In vitro</i> sister chromatid exchange assay: Negative in CHO with and without liver activation	Galloway et al., 1987; NCI/NTP, 2007	Sufficient study details reported.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: <i>In vitro</i> sister chromatid exchange assay: Negative in CHO with and without liver activation	Mast et al., 1982a	Sufficient study details were not available.
		Cyanuric acid: Negative for chromosomal aberrations in Chinese hamster lung cells with and without metabolic activation	OECD SIDS, 1999b	Reported in a secondary source with limited study details provided; 99.5% purity.
		Cyanuric acid: Negative for sister chromatid exchange in CHO cells with and without metabolic activation	OECD SIDS, 1999b; ECHA, 2011b	Sufficient study details reported in secondary sources; purity equivalent to 77% cyanurate.
	Chromosomal Aberrations <i>in vivo</i>	Melamine: <i>In vivo</i> mouse micronucleus test: The initial test gave a positive trend (P = 0.003) for chromosomal damage; however, both peripheral blood smears and the repeat bone marrow test were negative. The overall conclusion was that melamine does not induce chromosomal damage.	NTP, 1983; Shelby et al., 1993	Sufficient study details reported.
		Melamine: <i>In vivo</i> mouse micronucleus test: Negative without activation	Mast et al., 1982b	Sufficient study details were not available.
		Melamine: <i>In vivo</i> chromosome aberrations test in mice: Positive	NCI/NTP, 2007	Sufficient study details reported.
		Melamine: <i>In vivo</i> sister chromatid exchange assay in mice: Positive	NCI/NTP, 2007	Sufficient study details reported.
	DNA Damage and Repair	Melamine: <i>In vivo</i> and <i>in vitro</i> unscheduled DNA synthesis (UDS) test: None of the tested chemicals, including melamine, were genotoxic hepatocarcinogens in the <i>in vivo</i> assay, and melamine was negative for UDS in the <i>in vitro</i> assay.	Mirsalis et al., 1983	Sufficient study details were not available.
		Melamine: SOS/ <i>umu</i> test: Negative for its ability to result in DNA damage and induce the expression of the <i>umu</i> operon	Reifferscheid and Heil, 1996	Nonguideline study.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: DNA synthesis-inhibition test in Hela S3 cells: Inhibits DNA synthesis by 50% at >300 µM	Heil and Reifferscheid, 1992	Sufficient study details were not available.
	Other	Melamine: Sex-linked recessive lethal/reciprocal translocation: Results were considered equivocal based on 0.18% and 0.36% total lethal following oral and injection exposure, respectively, compared to control total lethal of 0.07% for oral and 0.09% for injection.	NCI/NTP, 2007	Sufficient study details reported.
		Melamine: Drosophila Muller-5 test: Negative for mutagenicity	Rohrborn, 1959	Sufficient study details were not available.
		Melamine: <i>Drosophila melanogaster</i> Sex-linked recessive lethal: No mutagenic effects were observed.	Luers and Rohrborn, 1963	Sufficient study details were not available.
		Melamine: <i>In vitro</i> flow cytometric DNA repair assay: Negative for genotoxic effects	Seldon et al., 1994	Nonguideline study.
		Melamine: Microscreen assay: Positive for genetic toxicity in <i>E.coli</i> WP2s	Rossmann et al., 1991	Nonguideline study.
		Melamine: Growth and genotoxic effects to bacteria (<i>Salmonella typhimurium</i>) and yeast (<i>Saccharomyces cerevisiae</i>): Non-mutagenic in <i>S.typhimurium</i> with or without S-9 mix. The growth of eight out of nine strains tested was delayed by 10 mM melamine during 24-hour cultivation. <i>S. cerevisiae</i> strain was tested, and did not recover its growth following 48-hour cultivation.	Ishiwata et al., 1991	Sufficient study details were not available.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		MODERATE: Potential for reproductive toxicity estimated based on data for a confidential analog that reports a NOAEL of 1,600 ppm (191-341 mg/kg/day) in rats orally exposed. Data based on the dissolution products indicate no effects on reproductive parameters in rats orally exposed to cyanuric acid for up to 3 generations or when exposed to melamine in a 13-week toxicity study. There were no data located regarding reproductive toxicity following exposure to melamine cyanurate.		
	Reproduction/ Developmental Toxicity Screen	Rat, oral; potential for reproductive toxicity NOAEL = 1,600 ppm (191-341 mg/kg/day) (Estimated by analogy)	Professional judgment	Estimated based on analogy to confidential analog; LOAEL not identified; study details not provided.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Cyanuric acid: Rat, oral (gavage), males exposed for 45 days, females exposed from 14 days prior to mating to lactation day (LD) 3; there were no effects on reproductive parameters including copulation index, fertility index, gestation length, numbers of corpora lutea or implantations, implantation index, gestation index, delivery index and behavior at delivery and lactation. NOAEL ≥600 mg/kg/day (highest dose tested)	OECD SIDS, 1999b	Reported in a secondary source; conducted according to OECD guidelines; 99.8% purity. LOAEL not established for reproductive toxicity.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Cyanuric acid: Rat, oral, exposure initiated at 36 days of age to F ₀ generation, 21 days to F ₁ and F ₂ parents and administered until termination of each generation; F ₀ males and females exposed minimum of 100 days, F ₁ and F ₂ male and females exposed a minimum of 120 days; There were no treatment-related reproductive effects observed. NOAEL F ₀ ≥~470 mg/kg-day (male) NOAEL F ₀ ≥~950 mg/kg-day (female)	ECHA, 2011b	Sufficient study details reported in secondary source; EU Method B.35 (two-generation reproduction toxicity test); test substance identified as sodium salt of cyanuric acid (equivalent to 77.5% cyanuric acid).
	Reproduction and Fertility Effects	Melamine: Reproductive dysfunction was observed at 0.5 mg/m ³ and included effects on spermatogenesis (genetic material, sperm morphology, motility, and count), effects on the embryo/fetus (fetal death), pre-implantation mortality (reduction in the number of implants per female), and total number of implants per corpora lutea.	Ubaidullajev, 1993	Study details, if present, were not translated into English; insufficient study details reported.
		Melamine: There were no treatment-related macroscopic or microscopic effects on mammary glands, ovaries, prostate, seminal vesicles, testes and uterus in rats and mice in a 13-week study.	OECD SIDS, 1999a	Study details, including administered dose information, were not provided.
Developmental Effects		MODERATE: Estimated based on analogy to nitrogen heterocycles. Data for dissolution products melamine and cyanuric acid indicate no developmental effects in rats orally exposed to cyanuric acid or melamine during gestation. There were no data located regarding developmental toxicity following exposure to melamine cyanurate.		
	Reproduction/ Developmental Toxicity Screen	Potential for developmental toxicity (Estimated by analogy)	Professional judgment	Estimated based on analogy to nitrogen heterocycles.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Cyanuric acid: Rat, oral (gavage), males exposed for 45 days, females exposed from 14 days prior to mating to LD 3. There were no effects in offspring parameters including number sex ratio, live birth and viability indices, body weight, or incidences of external and visceral abnormalities. NOAEL $\geq$ 600 mg/kg/day (highest dose tested)	OECD SIDS, 1999b	Reported in a secondary source; conducted according to OECD guidelines; 99.8% purity. LOAEL not established for developmental toxicity.
		Cyanuric acid: Rat, oral, exposure initiated at 36 days of age to F₀ generation, 21 days to F₁ and F₂ parents and administered until termination of each generation; F₀ males and females exposed minimum of 100 days, F₁ and F₂ male and females exposed a minimum of 120 days. There were no treatment-related developmental effects observed. NOAEL F₀ $\geq$ ~470 mg/kg-day (male) NOAEL F₀ $\geq$ ~950 mg/kg-day (female)	ECHA, 2011b	Sufficient study details reported in secondary source; EU Method B.35 (two-generation reproduction toxicity test); test substance identified as sodium salt of cyanuric acid (equivalent to 77.5% cyanuric acid).
	Prenatal Development	Melamine: Signs of maternal toxicity at 136 mg/kg-day included decreased body weight and feed consumption, hematuria (23/25 rats), indrawn flanks (7/25 rats), and piloerection (1/25 rats). No adverse effects on gestational parameters and no signs of developmental toxicity were noted. NOAEL $\geq$ 1,060 mg/kg-day	Hellwig et al., 1996 (as cited in OECD SIDS, 1999a)	Study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Cyanuric acid: Rat, oral (gavage); exposure on gestation days 6-15; There were no developmental effects observed. NOAEL = 5,000 mg/kg-day (highest dose tested)	ECHA, 2011b	Sufficient study details reported in a secondary source; EU method B.31 (prenatal developmental toxicity study); test substance identified as monosodium cyanurate monohydrate; 99% purity (equivalent to 77.4% cyanuric acid).
	Postnatal Development	Melamine: Only minor effects on the fetuses or litters, including a non-significant increase in resorptions in the group treated on the 4 th and 5 th days of gestation, were observed.	Thiersch, 1957	Sufficient study details were not available.
Neurotoxicity		LOW: Estimated to not have potential for neurotoxicity based on expert judgment.		
	Neurotoxicity Screening Battery (Adult)	Potential for neurotoxicity is expected to be low (Estimated)	Expert judgment	Estimated based on expert judgment.
Repeated Dose Effects		HIGH: Based on kidney toxicity following repeated oral exposure to melamine cyanurate and simultaneous co-exposure to melamine and cyanuric acid in rats. Kidney effects included increased plasma blood urea nitrogen and creatinine levels, the formation of precipitates in the kidney and acute renal failure. Repeated oral exposure to the dissolution product melamine also results in urinary bladder stones at doses in the moderate hazard range. The hazard designation for cyanuric acid is considered to be low.		

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine cyanurate: Rat, 7-day feeding study. Increased plasma BUN and creatinine levels at 666 ppm (66.6 mg/kg/day; nominal); severe kidney toxicity at 2,000 ppm (200 mg/kg-day); and formation of precipitates in the kidney. There were also mortality, signs of toxicity, decreased body weight and food consumption, changes in organ weights, gross pathology and non-neoplastic histopathology at higher doses. NOAEL: 200 ppm (~ 10 mg/kg-day) LOAEL: 660 ppm (~ 66.6 mg/kg-day) – based on increased plasma BUN and creatinine levels.	ECHA, 2011a	Reported in a secondary source. Study designed to test kidney toxicity; test substance identified as melaminzyanurat; purity >99%.
	Melamine and cyanuric acid co-exposure: Rat, oral 14-day oral (gavage) study of melamine and cyanuric acid co-exposure (each at 1.2, 12, 120 mg/kg-day); crystal formation in renal distal tubular lumens and collecting ducts were observed on day 3 in the 12 mg/kg-day group; crystal in proximal tubular lumens of renal cortex on day 3 and mortal acute renal failure on day 7 occurred at doses of 120 mg/kg-day. NOEL: 1.2 mg/kg-day LOEL: 12 mg/kg-day (based on crystals of melamine cyanurate in kidneys)	ECHA, 2011a	Reported in a secondary source. Study focused on renal crystal formation.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine and cyanuric acid co-exposure: 7-day feeding study in rats; Signs of toxicity evident, at doses of 33 mg/kg-day, there were pale yellow and enlarged kidneys and increased BUN and serum creatinine; histopathological evaluation showed golden brown crystals in renal tubules of all rats at this dose. There were no significant differences in kidney weights or crystals or tubular changes in rats administered melamine (200 mg/kg-day) or cyanuric acid (200 mg/kg-day) alone. NOAEL: 10 mg/kg-day LOAEL: 33 mg/kg-day (based on kidney toxicity)	ECHA, 2011a; Jacob et al., 2011	Both melamine and cyanurate were added to feed with a 1:1 ratio; primary source.
	Melamine and cyanuric acid co-exposure: Melamine and cyanuric acid orally (gavage) administered separately formed crystals of melamine cyanurate in kidney of rats. There was decreased creatinine clearance, increased in serum creatinine and BUN; increased absolute and relative kidney weight.	ECHA, 2011a	Reported in a secondary source. Effect levels not identified.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Rat 28-day dietary toxicity study: Clinical signs included a dose-related increase in pilo-erection, lethargy, bloody urine spots in the cage and on the pelage of animals, and chromodacryorrhea. The incidence of urinary bladder calculi and urinary bladder hyperplasia in treated animals was dose-dependent, with a significant relationship between the calculi and hyperplasia. Calculi composition indicated the presence of an organic matrix containing melamine, phosphorus, sulfur, potassium, and chloride. Crystals of dimelamine monophosphate were identified in the urine. NOAEL: 2,000 ppm (240 mg/kg/day), excluding the observed increase in water consumption and the incidence of crystalluria. LOAEL: 4,000 ppm (475 mg/kg/day) based on the formation of calculi.	RTI, 1983	Sufficient study details reported.
	Melamine: Rabbit and dog 28-day dietary toxicity study: No significant rise in the body temperature of rabbits was noted. Gross histological examination of the heart, lung, liver, spleen, thyroid, pancreas, intestines, kidneys and bladder did not show pathological changes. A zone of fat was found in the inner part of the renal cortex in two dogs, but also in the kidneys of 3 control dogs.	Lipschitz and Stokey, 1945	Sufficient study details were not available.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Rat 28-day dietary toxicity study: Incidence and size of bladder stones were directly related to the amount of substance administered. The larger stones were found to be unchanged melamine in a matrix of protein, uric acid and phosphate. Lowest effect dose (LED): 1,500 ppm (~125 mg/kg) in males.	American Cyanamid Company, 1984	Sufficient study details were not available.
	Melamine: Rat 90-day dietary toxicity study: One male rat receiving 18,000 ppm and two males receiving 6,000 ppm died. Mean body weight gain and feed consumption were reduced. Stones and diffuse epithelial hyperplasia in the urinary bladders were observed in male rats of all treatment groups. Focal epithelial hyperplasia was observed in only 1 male. A second and third 13-week repeated dose toxicity study was conducted in rats at a dose range of 750 to 18,000 ppm; bladder stones were observed at all dose levels. At 18,000 ppm, stones occurred in diets with and without the addition of ammonium chloride to drinking water. LOAEL = 700 ppm (72 mg/kg/day)	NTP, 1983; Melnick et al., 1984; ECHA, 2011a	Sufficient study details reported.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Mouse 90-day dietary toxicity study: a single female mouse died after receiving 9,000 ppm. Mean body weight gain relative to controls was depressed. The incidence of mice with bladder stones was dose-related and was greater in males than in females. Sixty percent of mice having bladder ulcers also had urinary bladder stones. Bladder ulcers were multifocal or associated with inflammation (cystitis). Epithelial hyperplasia and bladder stones were observed together in 2 mice. Also, epithelial cell atypia was seen. NOAEL: 6,000 ppm (600 mg/kg-day) LOAEL: 9,000 ppm (900 mg/kg-day)	NTP, 1983; Melnick et al., 1984	Sufficient study details reported.
	Melamine: Increased incidence of acute and chronic inflammation and epithelial hyperplasia of the urinary bladder was observed in mice following oral (feed) exposure for up to 103 weeks. There was also increased incidence of bladder stones in male mice. LOAEL = 2,250 mg/kg diet (lowest dose tested)	NTP, 1983; ECHA, 2011a	Repeated dose effects described in a carcinogenicity bioassay study.
	Melamine: Dog 1-year dietary toxicity study: crystalluria started 60 to 90 days into treatment, and persisted during the study period. No other effects attributable to melamine were observed.	American Cyanamid Company, 1955	Sufficient study details were not available.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Rat 30-month dietary toxicity study: Neither accumulation of calculi nor any treatment-related urinary bladder lesions were found.	Mast et al., 1982c (as described in EPA, 1992)	Sufficient study details were not available.
	Melamine: Rat 24- to 30-month dietary toxicity study: A dose-related trend for dilated glands in glandular gastric mucosa and inflammation in non-glandular gastric mucosa was observed. Urinary bladder calculi formation was not observed.	American Cyanamid Company, 1983 (as described in OECD SIDS, 1999a)	Sufficient study details were not available.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Cyanuric acid: Rat, oral (gavage), combined repeat dose and reproductive/developmental toxicity screening test; males exposed for 44 days, females exposed from 14 days prior to mating to LD 3. Toxic effects included: reddish urine, decreased body weight gain (males), increased erythrocytes and leukocytes in urine, decreased erythrocyte count, hemoglobin, and hematocrit (male), increased urea nitrogen and creatinine, decreased sodium (male), dilation of renal tubules, necrosis or hyperplasia of the tubular epithelium, increased basophilic tubules, neutrophilic infiltration, mineralization and fibrosis in the kids, hyperplasia of the mucosal epithelium in urinary bladder and vacuolization of the zona fasciculate in the adrenals, increased absolute and relative kidney weight and relative adrenal weights (both sexes), atrophic thymus (females). NOAEL = 150 mg/kg/day LOAEL = 600 mg/kg/day	OECD SIDS, 1999b	Reported in a secondary source with limited study details provided; 99.8% purity.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Cyanuric acid: Rat, oral (drinking water), 2-year toxicity and oncogenicity study; red urine in males at the highest dose was observed (371 mg/kg-day); there were no treatment-related changes in hematology, clinical chemistry, urinalysis, or organ weights; non-neoplastic lesion in urinary tracts and heart and urinary tract lesions of males exposed to 5,375 ppm (371 mg/kg-day) for 6-12 months; There were no treatment-related lesions in rats exposed for 18 or 24 months. NOAEL = 154 mg/kg-day (male) LOAEL = 371 mg/kg-day (male)	ECHA, 2011b	Sufficient study details reported in a secondary source; EU Method B.33 (combined chronic toxicity/carcinogenicity test); test substance identified as s-triazinetriol, monosodium salt (monosodium cyanurate monohydrate) 99.7% (equivalent to 77.4% cyanuric acid).
	Cyanuric acid: Mouse, oral (drinking water), 2-year toxicity and oncogenicity study; there were no treatment-related effects. NOAEL $\geq$ 1,520 mg/kg-day (male) NOAEL $\geq$ 1,580 mg/kg-day (female)	ECHA, 2011b	Sufficient study details reported in a secondary source; EU Method B.33 (combined chronic toxicity/carcinogenicity test); test substance identified as monosodium cyanurate monohydrate (equivalent to 77.5% cyanuric acid).
	Cyanuric acid: Mouse, oral (drinking water), 13-week subchronic toxicity study; there were no treatment related effects at doses as high as 1,523 mg/kg-day (males) and 1,582 mg/kg-day (females) NOAEL $\geq$ 1,523 mg/kg-day (male) NOAEL $\geq$ 1,582 mg/kg-day (female)	ECHA, 2011b	Sufficient study details reported in a secondary source; test substance identified as s-triazinetriol, monosodium salt (monosodium cyanurate monohydrate) 99.5% (equivalent to 76.9% cyanuric acid).

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Cyanuric acid: Rat, oral (drinking water, 13-week toxicity study; there were no treatment-related effects NOAEL ≥521 mg/kg-day (male) NOAEL ≥717 mg/kg-day (female)	ECHA, 2011b	Sufficient study details reported in a secondary source; test substance identified as s-triazinetriol, monosodium salt (monosodium cyanurate monohydrate) (equivalent to 77.34% cyanuric acid).
	Immune System Effects	Melamine: Did not inhibit the mitogenesis of B- and T- lymphocytes in an <i>in vitro</i> mouse lymphocyte mitogenesis test.	ECHA, 2011a	Reported in a secondary source.
Skin Sensitization		LOW: Estimated based on evidence of mild skin sensitization following exposure to the dissolution product cyanuric acid in mice. Melamine, also a dissolution product of melamine cyanurate, was not a skin sensitizer to humans or guinea pigs. There were no data located for melamine cyanurate for skin sensitization.		
	Skin Sensitization	Melamine: No evidence of primary dermal irritation or sensitization in a human patch test	American Cyanamid Company, 1955; Trochimowicz et al., 2001	Sufficient study details were not available.
		Melamine: Non-sensitizing to guinea pigs	Fasset and Roudabush, 1963/1981 (as described in OECD SIDS, 1999a and Trochimowicz et al., 2001); Trochimowicz et al., 2001	Sufficient study details were not available.
		Cyanuric acid: Borderline or mild skin sensitization in mice.	ECHA, 2011b	Sufficient study details reported in a secondary source; OECD guideline 429.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Estimated based on mild-to-moderate irritation to rabbit eyes following exposure to the dissolution products melamine and cyanuric acid. There were no data located for melamine cyanurate for eye irritation.		
	Eye Irritation	Melamine: Non-irritating to rabbit eyes	BASF, 1969 (as described in OECD SIDS, 1999a and IUCLID, 2000)	Sufficient study details were not available.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Non-irritating to rabbit eyes following 0.5 mL of 10% melamine	American Cyanamid Company, 1955; Trochimowicz et al., 2001	Sufficient study details were not available.
		Melamine: Mild irritant to rabbit eyes following exposure to 30 mg of dry powder	American Cyanamid Company, 1955; Trochimowicz et al., 2001	Sufficient study details were not available.
		Melamine: Slightly irritating to rabbit eyes	Marhold, 1972 (as described in IUCLID, 2000 and RTECS, 2009)	Sufficient study details were not available.
		Cyanuric acid: Slightly to moderately irritating to rabbit eyes	OECD SIDS, 1999b	Sufficient study details reported in secondary source; OECD guideline 405.
		Cyanuric acid: Slightly irritating to rabbit eyes; fully reversible within 3 days	ECHA, 2011b	Sufficient study details reported in a secondary source; OECD guideline 405.
Dermal Irritation		LOW: Estimated based on slight irritation to rabbit skin following exposure to the dissolution product cyanuric acid. Melamine, also a dissolution product of melamine cyanurate was not irritating to rabbit skin. There were no data located for melamine cyanurate for skin irritation.		
	Dermal Irritation	Melamine: Not irritating to rabbit skin	Rijcken, 1995 (as described in OECD SIDS, 1999a)	OECD 404 guideline study.
		Melamine: Not irritating to rabbit skin	BASF, 1969 (as described in OECD SIDS, 1999a and IUCLID, 2000)	Sufficient study details were not available.
		Melamine: Not irritating to rabbit skin	American Cyanamid Company, 1955; Trochimowicz et al., 2001	Sufficient study details were not available.
		Melamine: Not irritating to rabbit skin	Fasset and Roudabush, 1963/1981 (as described in OECD SIDS, 1999a and Trochimowicz et al., 2001); Trochimowicz et al., 2001	Sufficient study details were not available.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Cyanuric acid: Slightly irritating to rabbit skin	OECD SIDS, 1999b; ECHA, 2011b	Sufficient study details reported in a secondary source; OECD guideline 404.
Endocrine Activity		There were insufficient data located to describe the effect of melamine cyanurate on the endocrine system. In one study, melamine did not exhibit estrogenic activity <i>in vitro</i> in a yeast two-hybrid assay.		
		Melamine: Showed no estrogenic activity (no change in B-galactosidase activity) in an <i>in vitro</i> yeast two-hybrid assay in <i>Saccharomyces cerevisiae</i> Y 190	ECHA, 2011a	Reported in a secondary source. Nonguideline study.
Immunotoxicity		Located data were not sufficient to determine the hazard potential for this endpoint.		
	Immune System Effects	Melamine: Did not inhibit the mitogenesis of B- and T- lymphocytes in an <i>in vitro</i> mouse lymphocyte mitogenesis test.	ECHA, 2011a	Reported in a secondary source.
ECOTOXICITY				
ECOSAR Class		Melamine: Anilines (amino-meta), Melamines; Cyanuric acid: Aromatic triazines		
Acute Toxicity		LOW: Melamine cyanurate has low water solubility and therefore it is estimated that it will display no effects at saturation (NES) because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. A Low hazard potential is also assigned for the dissociation products, melamine and cyanuric acid, based on experimental data.		
Fish LC₅₀		Melamine cyanurate:	No data located.	Not amenable to estimation by available models that cannot accept chemicals with complex organic cations and anions.
		Melamine cyanurate: Melamine cyanurate has low water solubility and therefore it is estimated that it will display NES.	Professional judgment	The amount of melamine cyanurate dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
		Melamine : <i>Leuciscus idus melanotus</i> 48-hour LC ₅₀ >500 mg/L (Experimental)	OECD SIDS, 1999a	Study details reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: <i>Oryzias latipes</i> 48-hour LC ₅₀ = 1,000 mg/L (Experimental)	OECD SIDS, 1999a	Study details reported in a secondary source.
	Melamine: <i>Poecilia reticulata</i> 96-hour LC ₅₀ >3,000 mg/L (Experimental)	OECD SIDS, 1999a	Study details reported in a secondary source.
	Melamine: <i>Poecilia reticulata</i> 4,400 mg/L dose lethal to <10% (Experimental)	OECD SIDS, 1999a	Study details reported in a secondary source.
	Melamine: Fish 96-hour LC ₅₀ = 2,680 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	
	Melamine: Fish 96-hour LC ₅₀ = 391 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	
	Melamine: Fish 96-hour LC ₅₀ = 14,272 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Cyanuric acid: <i>Oryzias latipes</i> 96-hour LC ₅₀ >100 mg/L Semi-static and flow-through open conditions (Experimental)	OECD SIDS 1999b	99.7% purity; study details reported in a secondary source; separate experiments conducted with flow-through and semi-static conditions according to OECD TG203 guidelines.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Cyanuric acid: <i>Lepomis macrochirus</i> (fathead minnow) 96-hour LC ₅₀ >1,000 mg/L Static conditions (Experimental)	ECHA, 2011b	Purity unknown; not a guideline study but well-reported in a secondary source.
	Cyanuric acid: <i>Pimephales promelas</i> (bluegill sunfish) 96-hour LC ₅₀ >2,100 mg/L Static conditions (Experimental)	ECHA, 2011b	Well-reported in a secondary source.
	Cyanuric acid: Fish 96-hour LC ₅₀ = 72.04 mg/L (Estimated) ECOSAR: Aromatic triazines	ECOSAR version 1.11	
	Cyanuric acid: Fish 96-hour LC ₅₀ = 116.98 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid LC₅₀	Melamine cyanurate:	No data located.	Not amenable to estimation by available models that cannot accept chemicals with complex organic cations and anions.
	Melamine cyanurate: Melamine cyanurate has low water solubility and therefore it is estimated that it will display NES.	Professional judgment	The amount of melamine cyanurate dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
	Cyanuric acid: <i>Daphnia magna</i> 48-hour EC ₅₀ = 1,000 mg/L (immobilization); static, open-system conditions (Experimental)	OECD SIDS, 1999b	99.7% purity; study details reported in a secondary source; study conducted according to OECD TG202 guidelines guideline study;

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
			1,000 mg/L was the highest dose tested.
	Cyanuric acid: <i>Daphnia magna</i> 48-hour LC ₅₀ >1,000 mg/L Static conditions (Experimental)	ECHA, 2011b	Not a guideline study, but well-reported in a secondary source; purity not known.
	Cyanuric acid: Daphnid 48-hour LC ₅₀ = 34.65 mg/L (Estimated) ECOSAR: Aromatic triazines	ECOSAR version 1.11	
	Cyanuric acid: Daphnid 48-hour LC ₅₀ = 61.33 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Melamine: Daphnid 48-hour LC ₅₀ = 6.23 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	
	Melamine: Daphnid 48-hour LC ₅₀ = 144.34 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	
	Melamine: Daphnid 48-hour LC ₅₀ = 4,805 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Green Algae EC₅₀	Melamine cyanurate:	No data located.	Not amenable to estimation by available models that cannot accept chemicals with complex organic cations and anions.
	Melamine cyanurate: Melamine cyanurate has low water solubility and therefore it is estimated that it will display NES.	Professional judgment	The amount of melamine cyanurate dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
	Melamine: <i>Scenedesmus pannonicus</i> 4-day EC ₅₀ = 940 mg/L (Experimental); 4-day NOEC = 320 mg/L (Experimental)	OECD SIDS, 1999a	Reported in a secondary source, study details and test conditions were not provided.
	Melamine: Green algae 96-hour EC ₅₀ = 2.79 mg/L (Estimated) ECOSAR class: Anilines (amino-meta)	ECOSAR version 1.11	
	Melamine: Green algae 96-hour EC ₅₀ = 325 mg/L (Estimated) ECOSAR class: Melamines	ECOSAR version 1.11	
	Melamine: Green algae 96-hour EC ₅₀ = 4,396 mg/L (Estimated) ECOSAR class: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Cyanuric acid: <i>Selenastrum capricornutum</i> 72-hour EC ₅₀ = 620 mg/L (biomass) 72-hour NOEC = 62.5 mg/L (Experimental)	OECD SIDS, 1999b	Cyanuric acid (99.7% purity); study details reported in a secondary source; study conducted according to OECD TG201 guidelines.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Cyanuric acid: Green algae 96-hour EC ₅₀ = 0.11 mg/L (Estimated) ECOSAR: Aromatic triazines	ECOSAR version 1.11	
	Cyanuric acid: Green algae 96-hour EC ₅₀ = 56.87 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Chronic Aquatic Toxicity	LOW: Melamine cyanurate has low water solubility and therefore it is estimated that it will display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. A Low potential for hazard is also for assigned for the dissociation products, melamine and cyanuric acid, based on experimental data.		
Fish ChV	Melamine cyanurate:	No data located.	Not amenable to estimation by available models that cannot accept chemicals with complex organic cations and anions.
	Melamine cyanurate: Melamine cyanurate has low water solubility and therefore it is estimated that it will display NES.	Professional judgment	The amount of melamine cyanurate dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
	Melamine: <i>Jordanella floridae</i> 35-day NOEC ≥1,000 mg/L (Experimental)	OECD SIDS, 1999a	Reported in a secondary source, study details and test conditions were not provided.
	Melamine: <i>Salmo gairdneri</i> NOEC (macroscopic) = 500 mg/L (Experimental); NOEC (microscopic) <125 mg/L (Experimental)	OECD SIDS, 1999a	Reported in a secondary source, study details and test conditions were not provided.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: <i>Daphnia magna</i> 21-day LC ₅₀ = 32-56 mg/L, 21-day LC ₁₀₀ = 56 mg/L, 21-day NOEC = 18 mg/L (Experimental)	OECD SIDS, 1999a	Reported in a secondary source, study details and test conditions were not provided.
	Melamine: Fish ChV = 263 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	The toxicity value was estimated through application of acute to chronic ratios (ACRs).
	Melamine: Fish ChV = 1,102 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	
	Melamine: Fish ChV = 1,076 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Cyanuric acid: <i>Oncorhynchus mykiss</i> (rainbow trout) 28-day LOEC ≥1,000 mg/L (based on growth rate) Semi-static conditions (OECD guideline 215) (Experimental)	ECHA, 2011b	Guideline study; well-reported in a secondary source; >97% purity.
	Cyanuric acid: Fish ChV = 1.85 mg/L (Estimated) ECOSAR: Aromatic triazines	ECOSAR version 1.11	

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Cyanuric acid: Fish ChV = 11.38 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid ChV	Melamine cyanurate:	No data located.	Not amenable to estimation by available models that cannot accept chemicals with complex organic cations and anions.
	Melamine cyanurate: Melamine cyanurate has low water solubility and therefore it is estimated that it will display NES.	Professional judgment	The amount of melamine cyanurate dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
	Cyanuric acid: <i>Daphnia magna</i> 21-day EC ₅₀ = 65.9 mg/L (reproduction rate); NOEC = 32.0 mg/L Semi-static, open-system conditions (OECD TG202) (Experimental)	OECD SIDS, 1999b	99.7% purity; study details reported in a secondary source; guideline study.
	Cyanuric acid: <i>Daphnia magna</i> 21-day EC ₅₀ = 2,117 mg/L cyanuric acid (immobilization) LOEC = 378 mg/L cyanuric acid (mortality and reproduction) NOEC = 121 mg/L cyanuric acid Static conditions (OECD guideline 211) (Experimental)	ECHA, 2011b	Guideline study; well-reported in a secondary source; >97% purity.
	Cyanuric acid: Daphnid ChV = 1.49 mg/L (Estimated) ECOSAR class: Aromatic triazines	ECOSAR version 1.11	

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Cyanuric acid: Daphnid ChV = 6.37 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Melamine: Daphnid ChV = 0.078 mg/L (Estimated) ECOSAR class: Anilines (amino-meta)	ECOSAR version 1.11	
	Melamine: Daphnid ChV = 14.85 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	The toxicity value was estimated through application of ACRs.
	Melamine: Daphnid ChV = 343.93 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae ChV	Melamine cyanurate:	No data located.	Not amenable to estimation by available models that cannot accept chemicals with complex organic cations and anions.
	Melamine cyanurate: Melamine cyanurate has low water solubility and therefore it is estimated that it will display NES.	Professional judgment	The amount of melamine cyanurate dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.
	Melamine: Green algae ChV = 0.70 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	The toxicity value was estimated through application of ACRs.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Green algae ChV = 81.26 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	The toxicity value was estimated through application of ACRs.
	Melamine: Green algae ChV = 313.17 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Cyanuric acid: <i>Navicula pelliculosa</i> 72-hour EC ₅₀ = 2,041 mg/L cyanuric acid (biomass) 96-hour EC ₅₀ >3,780 mg/L cyanuric acid (biomass) 72-hour EC ₅₀ >3,780 mg/L cyanuric acid (growth rate) 96-hour EC ₅₀ >3,780 mg/L cyanuric acid (growth rate) 72-hour NOEC= 945 mg/L cyanuric acid 96-hour NOEC= 3,780 mg/L cyanuric acid Static conditions (ISO 10253) (Experimental)	ECHA, 2011b	Guideline study; well-reported in a secondary source; 99.1% purity.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Cyanuric acid: <i>Selenastrum capricornutum</i> 24-hour EC ₅₀ >1,000 mg/L (based on decreased <i>in vivo</i> chlorophyll alpha) 48-hour EC ₅₀ >1,000 mg/L (based on decreased <i>in vivo</i> chlorophyll alpha) 72-hour EC ₅₀ = 872 mg/L (based on decreased number of cells) 96-hour EC ₅₀ >712 mg/L (based on decreased number of cells) (Experimental)	ECHA, 2011b	Cyanuric acid; not a guideline study, but test procedures followed those of U.S. EPA Algal Assay Procedure: Bottle test (1971); well-reported in a secondary source; 77.5% purity.
		Cyanuric acid: Green algae ChV = 0.06 mg/L (Estimated) ECOSAR: Aromatic triazines	ECOSAR version 1.11	
		Cyanuric acid: Green algae ChV = 12.55 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
ENVIRONMENTAL FATE				
Transport		The measured low water solubility and estimated low vapor pressure indicate that melamine cyanurate is anticipated to partition predominantly to soil and sediment. Melamine cyanurate is not expected to migrate from soil to groundwater; aromatic amines tend to bind with humic matter in soil. It is not expected to volatilize from water. Volatilization from dry surface is also not expected based on its vapor pressure. In the atmosphere, melamine cyanurate is expected to exist solely in the particulate phase, based on its estimated vapor pressure. Particulates may be removed from air by wet or dry deposition.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment	Cutoff value for nonvolatile compounds based on the ionic nature of the material.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>1,000 (Estimated)	Professional judgment	Driven by structural analysis of melamine; aromatic amines form covalent bonds to humic matter in soils and sediments, binding irreversibly.
	Level III Fugacity Model			Not all input parameters for this model were available to run the estimation software (EPI) for the hydrogen bonded melamine cyanurate complex.
Persistence		VERY HIGH: Based on an experimental biodegradation study (OECD 301B) that demonstrated it was not readily biodegradable. This result is consistent with its negligible water solubility suggesting that it is not likely to be readily assimilated by microorganisms. Other degradative processes are not expected to be operative under environmental conditions. Melamine cyanurate is not expected to undergo complete dissolution under neutral conditions, nor under the pHs typically found in the environment. However, it rapidly dissociates under pH extremes. It is least soluble at pH 5 but most soluble at pH 3.5 and below. Melamine cyanurate does not contain chromophores that absorb at wavelengths >290 nm, indicating that it is not expected to be susceptible to direct photolysis by sunlight. The dissociation products, melamine and cyanuric acid salts, have experimental studies indicating that they are not expected to biodegrade under aerobic conditions when assessed as their corresponding neutral organic components. However, experimental studies indicate that cyanuric acid may degrade in anoxic environs.		
Water	Aerobic Biodegradation	Melamine cyanurate: Not readily biodegradable according to OECD Guideline 301 B (Ready Biodegradability: CO2 Evolution Test) (Measured)	ECHA, 2011a	Adequate, guideline study.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the magnitude of the estimated Henry's Law Constant.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Soil	Aerobic Biodegradation	Melamine: Not readily biodegradable: 0% biodegradation detected after 2 weeks with 100 ppm in 30 ppm activated sludge (OECD TG 301C) (Measured); 0% degradation after 28 days with 100 mg DOC/L in activated sludge (Zahn-Wellens test, OECD 302B) (Measured) Cyanuric Acid: Not readily biodegradable: 0% biodegradation detected after 2 weeks with 100 ppm in 30 ppm activated sludge (0% biochemical oxygen demand; 7.8% total organic carbon) (OECD TG 301C) (Measured)	MITI, 1998; OECD SIDS, 1999a	Adequate values from guideline studies for the melamine cyanurate complex components.
	Anaerobic Biodegradation	Cyanuric Acid: 100% degradation after 72-96 hours in anaerobic sewage at 10 µg/mL (Measured); 0% methane production after 1-year incubation in anoxic aquifer slurries (Measured)	Saldick, 1974; Adrian and Suflita, 1994	Inadequate, these data values are not applicable for the melamine cyanurate complex.
		Melamine: 0-8.9% nitrification was observed after 28 days incubation with bacteria in Webster silty clay loam under anaerobic conditions (Measured)	IUCLID, 2000	This value is for melamine. Reported in a secondary source, study details and test conditions were not provided.
	Soil Biodegradation w/ Product Identification	Melamine: Nitrification of melamine occurs in soil at a low rate (0.7 % organic N found as NO ₃ -N in week 10, and 0% in week 28). (Measured) Cyanuric Acid: 35 % nitrification at week 10 and 73 % at week 28. (Measured)	ECHA, 2011a	Nonguideline studies for the melamine cyanurate complex components.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	Melamine: 16 days (Estimated) Cyanuric Acid: 43 hours (Estimated)	EPI	

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine Cyanurate: The test substance was found to be thermally stable within the range 40-290°C according to a method similar to OECD Guideline 113 (Screening Test for Thermal Stability and Stability in Air) (Measured)	ECHA, 2011a	Nonguideline study.
Reactivity	Photolysis	Melamine Cyanurate, Melamine and Cyanuric acid: Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	These substances do not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	Melamine Cyanurate: The effect of pH on the solubility of melamine cyanurate has established that the minimum lies at pH 5. Decreasing the pH results in the formation of melamine cations and cyanuric acid in solution at pH 3.5 and below. Increasing the pH from 5 to 7.5 results in only a marginal increase in the dissolution of the melamine cyanurate complex. (Measured)	WHO, 2009	These results are consistent with that expected in a closed system. Under environmental conditions, infinite dilution may alter the equilibrium of the process towards enhanced dissolution.
Environmental Half-life		Melamine Cyanurate: >1 year (Estimated) Melamine: 75 days (Estimated) Cyanuric Acid: 30 days (Estimated)	Professional judgment; EPI; PBT Profiler	Melamine cyanurate is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to be removed by other degradative processes under environmental conditions because of its limited water solubility and limited partitioning to air.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Bioaccumulation		LOW: Melamine cyanurate has negligible water solubility under near neutral conditions and is expected to have poor bioavailability resulting in low potential for bioaccumulation. In addition, experimental BCF data for the organic components of melamine cyanurate, melamine and cyanuric acid are <100. These experimental values also indicate a low potential for bioaccumulation.		
	Fish BCF	Melamine Cyanurate: <100 (Estimated)	Professional judgment	This estimated value is based on the BCF results for the components melamine and cyanurate.
		Melamine: <0.38 in carp (<i>Cyprinus carpio</i>) after 6 weeks at 2.0 ppm concentration; <3.8 in carp (<i>Cyprinus carpio</i>) after 6 weeks at 0.2 ppm concentration (OECD 302B) (Measured) Cyanuric Acid: <0.1 in carp (<i>Cyprinus carpio</i>) after 6 weeks at 10 ppm concentration; <0.5 in carp (<i>Cyprinus carpio</i>) after 6 weeks at 1 ppm concentration (Measured)	MITI, 1998	Adequate values from guideline studies for the melamine cyanurate complex components.
	BAF	Melamine: <1 (Measured) Cyanuric Acid: 2.1 (Estimated)	OECD SIDS, 1999a; IUCLID, 2000; EPI	These values are for the individual components.
	Metabolism in Fish	Melamine: Uptake, bioaccumulation and elimination study with ¹⁴ C-melamine in fathead minnow (BCF = 0.48 and 0.26) and rainbow trout (BCF = 0.11, 0.05, 0.03) (Measured)	ECHA, 2011a	Nonguideline studies that support the low bioaccumulation potential for this substance.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Melamine Polyphosphate

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame-retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance, including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

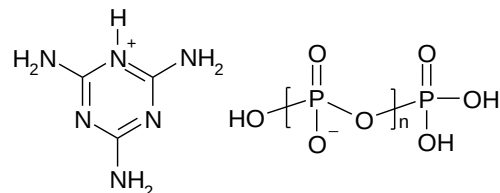
^s Based on analogy to experimental data for a structurally similar compound.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity **		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Melamine Polyphosphate ¹	15541-60-3	L	<i>M</i>	<i>M</i>	<i>L</i> ^s	<i>L</i>	<i>L</i> ^s	<i>M</i>	<i>L</i>		L	VL	L	L	<i>H</i>	<i>L</i>

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

¹ Hazard designations are based upon the component of the salt with the highest hazard designation, including the corresponding free acid or base.

Melamine Polyphosphate



CASRN: 15541-60-3

MW: >1,000

MF: C₃H₆N₆ · (H₃PO₄)_n

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: n(c(nc(n1)N)N)c1N(H)(H)OP(=O)(O)OP(=O)(O)O (n =1)

Synonyms: Diphosphoric acid, compound with 1,3,5-triazine-2,4,6-triamine; Polyphosphoric acids, compounds with melamine. The CASRN for the compound melamine pyrophosphate is 15541-60-3. The CASRN 218768-84-4 is associated with the product Melapur 200, not the chemical melamine polyphosphate.

Chemical Considerations: This alternative contains a polymeric moiety. Although the chain length of the polyphosphoric acid is not specified, the smaller, water-soluble polyphosphate ions were used in assessment (generally as the diphosphate ion, n=1). Melamine polyphosphate will freely dissociate under environmental conditions. Measured values from studies on the dissociated components were used to supplement data gaps as appropriate and EPI v 4.0 was used to estimate physical/chemical and environmental fate values in the absence of experimental data. Measured values from experimental studies were incorporated into the estimations.

Polymeric: Yes

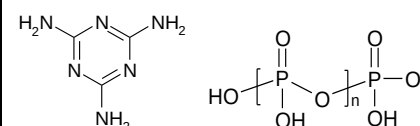
Oligomers: Melamine polyphosphate is a complex mixture consisting of melamine and polyphosphate chains of varying length.

Metabolites, Degradates and Transformation Products: Melamine (CASRN 108-78-1)

Analogs: Confidential structurally similar polymers; Polyphosphoric acid (8017-16-1) and melamine (108-78-1) are the dissociated components of this salt

Endpoint(s) using analog values: Reproductive effects; neurotoxicity; immunotoxicity

Analog Structure:



Structural Alerts: Aromatic amine, genetic toxicity (EPA, 2010)

Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community & IUCLID (Pakalin et al., 2007).

Hazard and Risk Assessments: Australian Safety and Compensation Council National Industrial Chemicals Notification and Assessment Scheme (NICNAS), October 30, 2006 (Australia, 2006); U.S. EPA Design for the Environment Alternatives Assessment for Flame Retardants in Printed Circuit Boards, Review Draft, November 8, 2008 (EPA, 2008).

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES				
Melting Point (°C)		>400 (Measured)	Submitted confidential study	Adequate; value for the melamine polyphosphate salt.
		>400 (Measured)	Australia, 2006	Adequate; value for the melamine polyphosphate salt.
Boiling Point (°C)		>300 (Estimated)	EPI; Professional judgment	As an organic salt, it is expected to decompose before boiling.
Vapor Pressure (mm Hg)		<10 ⁻⁸ (Estimated)	EPI; Boethling et al., 1997	Cutoff value for nonvolatile compounds
Water Solubility (mg/L)		20,000 (Measured)	Submitted confidential study	Adequate; value for the melamine polyphosphate salt.
		20,000 (Measured)	Australia, 2006	Adequate.
Log K_{ow}		<-2 (Estimated)	EPI	Cutoff value for highly water soluble substances.
Flammability (Flash Point)		Not highly flammable (Measured)	Submitted confidential study	Adequate.
Explosivity		Not a potential explosive (Measured)	Submitted confidential study	Adequate.
		Not a potential explosive (Measured)	Australia, 2006	Adequate.
Pyrolysis				No data located.
pH				No data located.
pK_a				No data located.
HUMAN HEALTH EFFECTS				
Toxicokinetics		No toxicokinetic data located for melamine polyphosphate or polyphosphoric acid; limited data for melamine indicate an elimination phase half-life of 2.7 hours from plasma and 3.0 hours for urine.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution,	Oral, Dermal or Inhaled	Melamine polyphosphate: Low for all routes (Estimated)	Professional judgment	Estimates based on physical/chemical properties.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Metabolism & Excretion		Melamine: The elimination phase half-life calculated from plasma data was 2.7 hours, and the urinary half-life was 3.0 hours. The renal clearance was determined to be 2.5 mL/minute.	Mast et al., 1983	Adequate, nonguideline study.
		Melamine: Distributed to stomach, small intestine, cecum, and large intestine, and found in blood and urine of rats.	ECHA, 2011b	Study details reported in a secondary source.
Acute Mammalian Toxicity		LOW: Melamine polyphosphate is expected to be of low hazard for acute toxicity based on experimental evidence for melamine polyphosphate, phosphoric acids and melamine. The weight of evidence indicates that when administered orally and dermally to rats, mice and rabbits, melamine polyphosphate, polyphosphoric acid, and melamine do not produce mortality at doses >1,000 mg/kg.		
Acute Lethality	Oral	Melamine polyphosphate: Rat (Gavage) LD ₅₀ >2,000 mg/kg	Ciba, 2005 (as described in Australia, 2006)	Sufficient study details reported.
		Melamine polyphosphate: Rat LD ₅₀ >2,000 mg/kg bw	NOTOX B.V., 1998 (as described in Australia, 2006)	Limited study details reported.
		Melamine polyphosphate: Rat (Gavage) LD ₅₀ >2,000 mg/kg	Submitted confidential study	Study details reported in a confidential study.
		Melamine polyphosphate: Rat LD ₅₀ >2,000 mg/kg	Submitted confidential study	Limited study details reported in a confidential study.
		Polyphosphoric acid: LD ₅₀ = 4,000 mg/kg (species unknown)	ARZNAD, 1957	Limited study details reported. The test substance was identified as polyphosphates, and was described as containing 1/3 Kurrol’s potassium salt and 2/3 pyrophosphate.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Rat LD ₅₀ = 3,161 mg/kg (male), 3,828 mg/kg (females)	NTP, 1983; Melnick et al., 1984	Sufficient study details reported.
		Melamine: Mouse LD ₅₀ = 3,296 mg/kg (male), 7,014 mg/kg (female)	NTP, 1983; Melnick et al., 1984	Sufficient study details reported.
		Melamine: Mouse LD ₅₀ = 4,550 mg/kg	Trochimowicz et al., 2001; American Cyanamid Company, 1955; May, 1979	Limited study details reported.
		Melamine: Rat LD ₅₀ = 3,160 mg/kg (male) and 3,850 mg/kg (female)	Trochimowicz et al., 2001	Limited study details reported.
		Melamine: Rat LD ₅₀ >6,400 mg/kg	BASF, 1969 (as described in OECD SIDS, 1999 and IUCLID, 2000a)	Limited study details reported.
		Melamine: LD ₅₀ ≈ 4,800 mg/kg	Hoechst, 1963 (as described in IUCLID, 2000a)	Limited study details reported.
	Dermal	Melamine: Rabbit LD ₅₀ >1,000 mg/L	Unknown, 1990	Limited study details reported.
	Inhalation	Melamine: Rat LC ₅₀ = 3,248 mg/L	Ubaidullajev, 1993	Limited study details reported.
Carcinogenicity		MODERATE: Estimated based on the dissolution product melamine. There is experimental evidence that oral melamine exposure causes carcinogenicity in animals; however, no data were located to support its carcinogenicity in humans. Tumor formation in animals appeared to happen in a mechanical nature under conditions in which it produced bladder calculi. No carcinogenicity data for melamine polyphosphate were located. The International Agency for Research on Cancer (IARC) classifies melamine as Group 3: <i>not classifiable as to its carcinogenicity to humans.</i>		
	OncoLogic Results	Melamine: Marginal (Estimated)	OncoLogic, 2008	
	Carcinogenicity (Rat and Mouse)	Melamine: Group 3: melamine is not classifiable as to its carcinogenicity to humans; there is inadequate evidence in humans for the carcinogenicity of melamine, and there is sufficient evidence in experimental animals for the carcinogenicity of melamine under conditions in which it produces bladder calculi.	IARC, 1999	IARC classification statement.

Melamine Polyphosphate CASRN 15541-60-3

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Significant formation of transitional cell carcinomas in the urinary bladder of male rats and significant chronic inflammation in the kidney of dosed female rats were observed. Carcinoma formation was significantly correlated with the incidence of bladder stones. A transitional-cell papilloma was observed in the urinary bladder of a single high dose male rat, and compound related lesions were observed in the urinary tract of dosed animals.	NTP, 1983; Huff, 1984; Melnick et al., 1984	Sufficient study details reported.
		Melamine: Increased incidence of acute and chronic inflammation and epithelial hyperplasia of the urinary bladder were observed in male mice. Bladder stones and compound-related lesions were observed in the urinary tract of test animals. Melamine was not considered carcinogenic.	NTP, 1983; Huff, 1984; Melnick et al., 1984	Sufficient study details reported.
		Melamine: Melamine-induced proliferative lesions of the rat urinary tract were directly due to the irritant stimulation of calculi, and not to molecular interactions between melamine or its metabolites with the bladder epithelium.	Okumura et al., 1992	Sufficient study details reported.

Melamine Polyphosphate CASRN 15541-60-3			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Water intake, used as an index of urinary output, was increased by NaCl treatment. Calculus formation resulting from melamine administration was suppressed dose-dependently by the simultaneous NaCl treatment. The main constituents of calculi were melamine and uric acid (total contents 61.1–81.2%). The results indicate that melamine-induced proliferative lesions of the urinary tract of rats were directly due to the irritation stimulation of calculi, and not molecular interactions between melamine itself or its metabolites with the bladder epithelium.	Ogasawara et al., 1995	Sufficient study details reported.
	Melamine: As an initiator, melamine caused no significant increase in papillomas per mouse when compared to controls.	Perrella and Boutwell, 1983	Nonguideline study.
	Melamine: Diffuse papillary hyperplasia of the bladder epithelium and bladder calculi were observed in all melamine treated rats. Elevated spermidine/spermine N1-acetyltransferase activity following melamine treatment was considered to be an indicator of cell proliferation.	Matsui-Yuasa et al., 1992	Nonguideline study.
	Melamine: Decreased antitumor activity was correlated with increasing demethylation; melamine was considered inactive as an antitumor drug.	Rutty and Connors, 1977	Limited study details reported.
	Melamine: In an <i>in vitro</i> cytotoxicity study in cultured ADJ/PC6 plasmacytoma ascites tumor cells, the ID ₅₀ was 470 µg/mL after 72 hours of treatment.	Rutty and Abel, 1980	Limited study details reported.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Chronic Toxicity/ Carcinogenicity	Melamine: No effects were observed in rats fed 1,000 ppm of melamine. Four of the 10 rats fed 10,000 ppm melamine had bladder stones associated with the development of benign papillomas.	Anonymous, 1958 (as described in EPA, 1992)	Limited study details reported.
		Melamine: Increased incidence of urinary bladder stones (6/20 rats) was noted in the 10,000 ppm dose group, and was associated with an increase in benign papillomata. The NOAEL was determined to be 1,000 ppm (67 mg/kg).	American Cyanamid Company, 1955	Limited study details reported.
Genotoxicity		MODERATE: Melamine polyphosphate is estimated to be a moderate hazard for genotoxicity based on the data for melamine. For melamine, positive results were observed for <i>in vivo</i> chromosome aberration and sister chromatid exchange assays conducted by National Toxicology Program (NTP) in 1988 and 1989. Available <i>in vitro</i> genotoxicity testing was conducted with metabolic activation systems from the liver. NTP suggests this may not account for potential activation from bladder epithelial cells, which is the target organ. Proposed genotoxicity testing using a metabolic activation system from bladder epithelial cells (NTP, 1983) was never conducted (Personal Communication, 2007; 2008).		
	Gene Mutation <i>in vitro</i>	Melamine: Bacterial forward mutation assay: Negative with and without liver activation	Haworth et al., 1983; NCI/NTP, 2007	Sufficient study details reported.
		Melamine: Bacterial forward mutation assay: Negative	Seiler, 1973	Limited study details reported.
		Melamine: Bacterial reverse mutation assay: Negative with and without liver activation	Lusby et al., 1979	Limited study details reported.
		Melamine: Bacterial reverse mutation assay: Negative with and without unspecified metabolic activation	Mast et al., 1982a	Limited study details reported.
		Melamine: <i>In vitro</i> mouse lymphoma test: Negative with and without liver activation	McGregor et al., 1988; NCI/NTP, 2007	Sufficient study details reported.

Melamine Polyphosphate CASRN 15541-60-3

Melamine Polyphosphate CASRN 15541-60-3			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Chinese hamster ovary (CHO) cells/hypoxanthine-guanine phosphoribosyl-transferase forward mutation assay: Negative with and without liver activation	Mast et al., 1982a	Limited study details reported.
Gene Mutation <i>in vivo</i>			No data located.
Chromosomal Aberrations <i>in vitro</i>	Melamine: <i>In vitro</i> chromosomal aberrations test: Negative in CHO with and without liver activation	Galloway et al., 1987; NCI/NTP, 2007	Sufficient study details reported.
	Melamine: <i>In vitro</i> sister chromatid exchange assay: Negative in CHO with and without liver activation	Galloway et al., 1987; NCI/NTP, 2007	Sufficient study details reported.
	Melamine: <i>In vitro</i> sister chromatid exchange assay: Negative in CHO with and without liver activation	Mast et al., 1982a	Limited study details reported.
Chromosomal Aberrations <i>in vivo</i>	Melamine: <i>In vivo</i> mouse micronucleus test: The initial test gave a positive trend (P = 0.003) for chromosomal damage; however, both peripheral blood smears and the repeat bone marrow test were negative. The overall conclusion was that melamine does not induce chromosomal damage.	NTP, 1983; Shelby et al., 1993	Sufficient study details reported.
	Melamine: <i>In vivo</i> mouse micronucleus test: Negative without activation	Mast et al., 1982b	Limited study details reported.
	Melamine: <i>In vivo</i> chromosome aberrations test in mice: Positive	NCI/NTP, 2007	Sufficient study details reported.
	Melamine: <i>In vivo</i> sister chromatid exchange assay in mice: Positive	NCI/NTP, 2007	Sufficient study details reported.

Melamine Polyphosphate CASRN 15541-60-3

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
DNA Damage and Repair	Melamine: <i>In vivo</i> and <i>in vitro</i> unscheduled DNA synthesis (UDS) test: None of the tested chemicals, including melamine, were genotoxic hepatocarcinogens in the <i>in vivo</i> assay, and melamine was negative for UDS in the <i>in vitro</i> assay.	Mirsalis et al., 1983	Limited study details reported.
	Melamine: SOS/ <i>umu</i> test: Negative for its ability to result in DNA damage and induce the expression of the <i>umu</i> operon	Reifferscheid and Heil, 1996	Nonguideline study.
	Melamine: DNA synthesis-inhibition test in Hela S3 cells: Inhibits DNA synthesis by 50% at greater than 300 µM	Heil and Reifferscheid, 1992	Limited study details reported.
Other	Melamine: Sex-linked recessive lethal/reciprocal translocation: Results were considered equivocal based on 0.18% and 0.36% total lethal following oral and injection exposure, respectively, compared to control total lethal of 0.07% for oral and 0.09% for injection.	NCI/NTP, 2007	Sufficient study details reported.
	Melamine: <i>Drosophila</i> Muller-5 test: Negative for mutagenicity	Rohrborn, 1959	Limited study details reported.
	Melamine: <i>Drosophila melanogaster</i> Sex-linked recessive lethal: No mutagenic effects were observed	Luers and Rohrborn, 1963	Limited study details reported.
	Melamine: <i>In vitro</i> flow cytometric DNA repair assay: Negative for genotoxic effects	Seldon et al., 1994	Nonguideline study.
	Melamine: Microscreen assay: Positive for genetic toxicity in <i>E. coli</i> WP2 cells	Rossman et al., 1991	Nonguideline study.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Growth and genotoxic effects to bacteria (<i>Salmonella typhimurium</i>) and yeast (<i>Saccharomyces cerevisiae</i>): Non-mutagenic in <i>S.typhimurium</i> with or without S-9 mix. The growth of eight out of nine strains tested was delayed by 10 mM melamine during 24 hour cultivation. <i>S. cerevisiae</i> strain was tested, and did not recover its growth following 48 hour cultivation.	Ishiwata et al., 1991	Limited study details reported.
Reproductive Effects		LOW: Estimated based on analogy to structurally similar compound and professional judgment. There were no data for melamine polyphosphate located. Experimental data for the melamine component also support a low hazard designation.		
	Reproduction/ Developmental Toxicity Screen	Rat, oral; potential for reproductive toxicity (Estimated by analogy)	Professional judgment	Estimated based on analogy to confidential analog; LOAEL not identified; study details not provided.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects	Melamine: Reproductive dysfunction was observed at 0.5 mg/m ³ and included effects on spermatogenesis (genetic material, sperm morphology, motility, and count), effects on the embryo/fetus (fetal death), pre-implantation mortality (reduction in the number of implants per female), and total number of implants per corpora lutea.	Ubaidullajev, 1993	Study details, if present, were not translated into English.
		Melamine: There were no treatment-related macroscopic or microscopic effects on mammary glands, ovaries, prostate, seminal vesicles, testes and uterus in rats and mice in a 13-week study.	OECD SIDS, 1999	Study details, including administered dose information, were not provided.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Developmental Effects		LOW: Melamine polyphosphate is estimated to have Low hazard for developmental effects based on the data for melamine. For melamine, no adverse effects on gestational parameters, no signs of developmental toxicity.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development	Melamine: Signs of maternal toxicity at 136 mg/kg-day included decreased body weight and feed consumption, hematuria (23/25 rats), indrawn flanks (7/25 rats), and piloerection (1/25 rats). No adverse effects on gestational parameters and no signs of developmental toxicity were noted. NOAEL $\geq$ 1,060 mg/kg-day	Hellwig et al., 1996 (as cited in OECD SIDS, 1999)	Sufficient study details reported.
	Postnatal Development	Melamine: Only minor effects on the fetuses or litters, including a non-significant increase in resorptions in the group treated on the 4 th and 5 th days of gestation, were observed.	Thiersch, 1957	Sufficient study details were not available.
Neurotoxicity		LOW: Based on professional judgment through analogy to structurally similar polymers.		
	Neurotoxicity Screening Battery (Adult)	Potential for neurotoxicity is expected to be low (Estimated)	Professional judgment	Estimated based on analogy and professional judgment.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects		MODERATE: Melamine polyphosphate is expected to have moderate hazard for repeated dose effects based on the data for melamine. Stones and diffuse epithelial hyperplasia in the urinary bladders were observed in male rats at doses as low as 700 ppm (72 mg/kg/day).		
		Polyphosphoric Acid: Rat Repeated-Dose Toxicity Study: An oral repeated-dose toxicity test in rats resulted in a TD _{Lo} of 450 mg/kg. The test substance was identified as polyphosphates, and was described as containing 1/3 Kurrol's potassium salt and 2/3 pyrophosphate. Toxic effects included changes in liver weight, changes in tubules (including acute renal failure, acute tubular necrosis), and weight loss or decreased weight gain.	ARZNAD, 1957	Sufficient study details were not available.

Melamine Polyphosphate CASRN 15541-60-3

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Rat 28-day dietary toxicity study: Clinical signs included a dose-related increase in pilo-erection, lethargy, bloody urine spots in the cage and on the pelage of animals, and chromodacryorrhea. The incidence of urinary bladder calculi and urinary bladder hyperplasia in treated animals was dose-dependent, with a significant relationship between the calculi and hyperplasia. Calculi composition indicated the presence of an organic matrix containing melamine, phosphorus, sulfur, potassium, and chloride. Crystals of dimelamine monophosphate were identified in the urine. NOAEL = was estimated to be 2,000 ppm (240 mg/kg/day), excluding the observed increase in water consumption and the incidence of crystalluria. LOAEL was determined to be 4,000 ppm (475 mg/kg/day) based on the formation of calculi.	RTI, 1983	Sufficient study details reported.
		Melamine: Rabbit and dog 28-day dietary toxicity study: No significant rise in the body temperature of rabbits was noted. Gross histological examination of the heart, lung, liver, spleen, thyroid, pancreas, intestines, kidneys and bladder did not show pathological changes. A zone of fat was found in the inner part of the renal cortex in two dogs, but also in the kidneys of 3 control dogs.	Lipschitz and Stokey, 1945	Sufficient study details were not available.

Melamine Polyphosphate CASRN 15541-60-3

Melamine Polyphosphate CASRN 15541-60-3			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Rat 28-day dietary toxicity study: Incidence and size of bladder stones were directly related to the amount of substance administered. The larger stones were found to be unchanged melamine in a matrix of protein, uric acid and phosphate. Lowest effective dose: 1,500 ppm (~125 mg/kg) in males.	American Cyanamid Company, 1984	Sufficient study details were not available.
Chronic	Melamine: Rat 90-day dietary toxicity study: one male rat receiving 18,000 ppm and two males receiving 6,000 ppm died. Mean body weight gain and feed consumption were reduced. Stones and diffuse epithelial hyperplasia in the urinary bladders were observed in male rats of all treatment groups. Focal epithelial hyperplasia was observed in only 1 male. A second and third 13-week repeated dose toxicity study was conducted in rats at a dose range of 750 to 18,000 ppm; bladder stones were observed at all dose levels. LOAEL = 700 ppm (72 mg/kg/day)	NTP, 1983; Melnick et al., 1984; ECHA, 2011b	Sufficient study details reported.

Melamine Polyphosphate CASRN 15541-60-3

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Mouse 90-day Dietary Toxicity Study: A single female mouse died after receiving 9,000 ppm. Mean body weight gain relative to controls was depressed. The incidence of mice with bladder stones was dose-related and was greater in males than in females. Sixty percent of mice having bladder ulcers also had urinary bladder stones. Bladder ulcers were multifocal or associated with inflammation (cystitis). Epithelial hyperplasia and bladder stones were observed together in 2 mice. Also, epithelial cell atypia was seen. NOAEL: 6,000 ppm (600 mg/kg-day) LOAEL: 9,000 ppm (900 mg/kg-day)	NTP, 1983; Melnick et al., 1984	Sufficient study details reported.
		Melamine: Increased incidence of acute and chronic inflammation and epithelial hyperplasia of the urinary bladder was observed in mice following oral (feed) exposure for up to 103 weeks. There was also increased incidence of bladder stones in male mice. LOAEL = 2,250 ppm (lowest dose tested)	NTP, 1983; ECHA, 2011a	Repeated dose effects described in a carcinogenicity bioassay study.
		Melamine: Dog 1-year dietary toxicity study: crystalluria started 60 to 90 days into treatment, and persisted during the study period. No other effects attributable to melamine were observed.	American Cyanamid Company, 1955	Sufficient study details were not available.
		Melamine: Rat 30-month dietary toxicity study: neither accumulation of calculi nor any treatment-related urinary bladder lesions were found.	Mast et al., 1982c (as cited in EPA, 1992)	Sufficient study details were not available.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Rat 24- to 30-month dietary toxicity study: a dose-related trend for dilated glands in glandular gastric mucosa and inflammation in non-glandular gastric mucosa was observed. Urinary bladder calculi formation was not observed.	American Cyanamid Company, 1983 (as cited in OECD SIDS, 1999)	Sufficient study details were not available.
	Immune System Effects	Melamine: Did not inhibit the mitogenesis of B- and T- lymphocytes in an <i>in vitro</i> mouse lymphocyte mitogenesis test.	ECHA, 2011b	Reported in a secondary source.
Skin Sensitization		LOW: Melamine polyphosphate is not expected to be a skin sensitizer based on the data for melamine.		
	Skin Sensitization	Melamine: No evidence of primary dermal irritation or sensitization in a human patch test	American Cyanamid Company, 1955; Trochimowicz et al., 2001	Limited study details reported.
		Melamine: Non-sensitizing to guinea pigs	Fasset and Roudabush, 1963/1981 (as cited in OECD SIDS, 1999 and Trochimowicz et al., 2001); Trochimowicz et al., 2001	Limited study details reported.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Melamine polyphosphate is slightly irritating to rabbit eyes.		
	Eye Irritation	Melamine polyphosphate: Slightly irritating	NOTOX B.V., 1998 (as cited in Australia, 2006)	Limited study details reported.
		Melamine polyphosphate: Slightly irritating	Submitted confidential study	Limited study details reported.
		Melamine: Non-irritating to rabbit eyes	BASF, 1969 (as cited in OECD SIDS, 1999 and IUCLID, 2000a)	Limited study details reported.
		Melamine: Non-irritating to rabbit eyes following 0.5 mL of 10% melamine	American Cyanamid Company, 1955; Trochimowicz et al., 2001	Limited study details reported.
		Melamine: Mild irritant to rabbit eyes following exposure to 30 mg of dry powder	American Cyanamid Company, 1955; Trochimowicz et al., 2001	Limited study details reported.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Slightly irritating to rabbit eyes	Marhold, 1972 (as cited in IUCLID, 2000a and RTECS, 2009)	Limited study details reported.
Dermal Irritation		VERY LOW: Melamine polyphosphate is not a skin irritant in rabbits.		
	Dermal Irritation	Melamine polyphosphate: Not irritating	NOTOX B.V., 1998 (as cited in Australia, 2006)	Limited study details reported.
		Melamine polyphosphate: Not irritating	Submitted confidential study	Limited study details reported.
		Melamine: Not irritating to rabbit skin	Rijcken, 1995 (as cited in OECD SIDS, 1999)	Organisation of Economic Cooperation and Development (OECD) 404 guideline study
		Melamine: Not irritating to rabbit skin	BASF, 1969 (as cited in OECD SIDS, 1999 and IUCLID, 2000a)	Limited study details reported.
		Melamine: Not irritating to rabbit skin	American Cyanamid Company, 1955; Trochimowicz et al., 2001	Limited study details reported.
		Melamine: Not irritating to rabbit skin	Fasset and Roudabush, 1963/1981 (as cited in OECD SIDS, 1999 and Trochimowicz et al., 2001); Trochimowicz et al., 2001	Limited study details reported.
Endocrine Activity		There were insufficient data located to describe the effect of melamine polyphosphate on the endocrine system. In one study, melamine did not exhibit estrogenic activity <i>in vitro</i> in a yeast two-hybrid assay.		
		Melamine: Showed no estrogenic activity (no change in B-galactosidase activity) in an <i>in vitro</i> yeast two-hybrid assay in <i>Saccharomyces cerevisiae</i> Y 190	ECHA, 2011a	Reported in a secondary source. Nonguideline study.
Immunotoxicity		Potential for immunotoxic effects based on analogy to structurally similar polymers and professional judgment.		
	Immune System Effects	Melamine: Did not inhibit the mitogenesis of B- and T- lymphocytes in an <i>in vitro</i> mouse lymphocyte mitogenesis test.	ECHA, 2011b	Reported in a secondary source.
ECOTOXICITY				
ECOSAR Class		Anilines (amino-meta), Triazines		

Melamine Polyphosphate CASRN 15541-60-3			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Acute Toxicity	LOW: Melamine polyphosphate is expected to be of low hazard for acute toxicity to aquatic organisms based on experimental data for melamine polyphosphate and melamine. For melamine, the weight of evidence suggests that the acute values are >100 mg/L. For melamine polyphosphate, no effects were observed at the highest concentration tested (3.0 mg/L). Melamine polyphosphate is not predicted to cause eutrophication based on laboratory testing.		
Fish LC ₅₀	Melamine polyphosphate: Freshwater fish 96-hour LC ₅₀ = 100 mg/L (Experimental)	Ciba, 2005 (as cited in Australia, 2006)	Reported in a secondary source, study details and test conditions were not reported.
	Melamine: <i>Leuciscus idus melanotus</i> 48-hour LC ₅₀ >500 mg/L (Experimental)	OECD SIDS, 1999	Study details reported in secondary source.
	Melamine: <i>Oryzias latipes</i> 48-hour LC ₅₀ = 1,000 mg/L (Experimental)	OECD SIDS, 1999	Study details reported in secondary source.
	Melamine: <i>Poecilia reticulata</i> 96-hour LC ₅₀ >3,000 mg/L (Experimental)	OECD SIDS, 1999	Study details reported in secondary source.
	Melamine: <i>Poecilia reticulata</i> 4,400 mg/L dose lethal to <10% (Experimental)	OECD SIDS, 1999	Study details reported in secondary source.
	Melamine: Fish 96-hour LC ₅₀ = 2,680 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	
	Melamine: Fish 96-hour LC ₅₀ = 391 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	
	Melamine: Fish 96-hour LC ₅₀ = 14,272 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid LC ₅₀	Melamine polyphosphate: Daphnia magna 48-hour EC ₅₀ >100 mg/L	Ciba, 2005 (as cited in Australia, 2006)	Reported in a secondary source, study details and test conditions were not reported.

Melamine Polyphosphate CASRN 15541-60-3			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: <i>Daphnia magna</i> 48-hour LC ₅₀ >2,000 mg/L (Experimental)	OECD SIDS, 1999	Study details reported in secondary source.
	Melamine: Daphnid 48-hour LC ₅₀ = 6.23 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	
	Melamine: Daphnid 48-hour LC ₅₀ = 144.34 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	
	Melamine: Daphnid 48-hour LC ₅₀ = 4,805 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae EC ₅₀	Melamine polyphosphate: <i>Selenastrum capricornutum</i> 96-hour EC ₅₀ >3.0 mg/L (Experimental); 96-hour NOEC = 3.0 mg/L (Experimental)	Submitted confidential study	No effects observed at highest concentration tested.
	Melamine polyphosphate: <i>Selenastrum capricornutum</i> 96-hour EC ₅₀ >3.0 mg/L (Experimental); 96-hour NOEC = 3.0 mg/L (Experimental)	Australia, 2006	Reported in a secondary source, study details and test conditions were not provided; no effects observed at highest concentration tested.
	Melamine polyphosphate: In a 96-hour control growth test (<i>Selenastrum capricornutum</i>), melamine polyphosphate causes increased algal growth, but growth is 95% less than growth in standard medium with adequate phosphorous. This indicates that melamine polyphosphate is not a good source of phosphorous for algal growth and does not cause eutrophication. (Experimental)	Submitted confidential study	Sufficient study details reported in a confidential study.

Melamine Polyphosphate CASRN 15541-60-3			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Green algae 96-hour EC ₅₀ = 2.79 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	
	Melamine: Green algae 96-hour EC ₅₀ = 325 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	
	Melamine: Green algae 96-hour EC ₅₀ = 4,396 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Melamine: <i>Scenedesmus pannonicus</i> 4-day EC ₅₀ = 940 mg/L (Experimental); 4-day NOEC = 320 mg/L (Experimental)	OECD SIDS, 1999	Reported in a secondary source, study details and test conditions were not provided.
Chronic Aquatic Toxicity	LOW: Melamine polyphosphate is expected to be of low hazard for chronic toxicity to aquatic organisms based on experimental data for melamine. For melamine, the weight of evidence suggests that the ChVs are >10 mg/L.		
Fish ChV	Melamine: <i>Jordanella floridae</i> 35-day NOEC ≥1,000 mg/L (Experimental)	OECD SIDS, 1999	Reported in a secondary source, study details and test conditions were not provided.
	Melamine: <i>Salmo gairdneri</i> NOEC (macroscopic) = 500 mg/L (Experimental); NOEC (microscopic) <125 mg/L (Experimental)	OECD SIDS, 1999	Reported in a secondary source, study details and test conditions were not provided.
	Melamine: Fish ChV = 263 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	The toxicity value was estimated through application of acute to chronic ratios (ACRs).
	Melamine: Fish ChV = 1,102 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	

Melamine Polyphosphate CASRN 15541-60-3			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Melamine: Fish ChV = 1,076 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid ChV	Melamine: <i>Daphnia magna</i> 21-day LC ₅₀ = 32-56 mg/L, 21-day LC ₁₀₀ = 56 mg/L, 21day NOEC = 18 mg/L (Experimental)	OECD SIDS, 1999	Reported in a secondary source, study details and test conditions were not provided.
	Melamine: Daphnid ChV = 0.078 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	
	Melamine: Daphnid ChV = 14.85 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	The toxicity value was estimated through application of ACRs.
	Melamine: Daphnid ChV = 343.93 mg/L (Estimated) ECOSAR class: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae ChV	Melamine: Green algae ChV = 0.70 mg/L (Estimated) ECOSAR: Anilines (amino-meta)	ECOSAR version 1.11	The toxicity value was estimated through application of ACRs.
	Melamine: Green algae ChV = 81.26 mg/L (Estimated) ECOSAR: Melamines	ECOSAR version 1.11	

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: Green algae ChV = 313.17 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
ENVIRONMENTAL FATE				
Transport		Melamine polyphosphate has a high measured water solubility of 20 g/L and its Henry's Law Constant and vapor pressure are below cutoff values. It is expected to partition predominately to water and soil. It may migrate from soil into groundwater. As a salt, volatilization from either wet or dry surfaces is not expected to be an important fate process.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	EPI; Professional judgment	Cutoff value for nonvolatile compounds.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	Melamine polyphosphate: 13 (Estimated)	EPI	
	Level III Fugacity Model	Melamine polyphosphate: Air = 0% Water = 37% Soil = 63% Sediment = 0% (Estimated)	EPI	

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Persistence		HIGH: Melamine polyphosphate is expected to show high persistence in the environment based on the data for melamine, which is expected to be fully dissociated under environmental conditions. The weight of evidence suggests that melamine will biodegrade, at rates consistent with a High hazard designation. Although pure culture studies showed evidence of biodegradation by enzymatic hydrolytic deamination in less than 10 days, an original MITI test detected less than 30% degradation after 14 days and two separate guideline OECD 302B studies observed no degradation after 28 days and 16% degradation after 20 days. This results in an expected environmental persistence half-life between 60 and 180 days. Degradation of melamine or its cation by hydrolysis or direct photolysis is not expected to be significant as the functional groups present on this molecule do not tend to undergo these reactions under environmental conditions. Polyphosphoric acid is expected to have low persistence in the environment. The weight of evidence suggests that polyphosphoric acid will hydrolyze under environmental conditions. The phosphates formed are expected to participate in natural cycles and be readily assimilated.		
Water	Aerobic Biodegradation	Melamine polyphosphate: Weeks (Primary survey model) Months (Ultimate survey model) (Estimated)	EPI	These values are for the dissociated component, melamine. Reported in a secondary source, study details and test conditions were not provided.
		Melamine: 16% removal after 20 days with activated sludge, 14% removal after 10 days with adapted sludge (Measured)	OECD SIDS, 1999	
		Melamine: 0% removal after 28 days with activated sludge (Measured)	OECD SIDS, 1999	
		Melamine: 0% removal after 14 days with activated sludge (Measured)	OECD SIDS, 1999	
		Melamine: <30% removal after 14 days with activated sludge (Measured)	OECD SIDS, 1999	
		Melamine: <1% removal after 5 days with an adapted inoculum (Measured)	IUCLID, 2000a	
		Melamine: 0% removal after 14 days with activated sludge (Measured)	IUCLID, 2000a	
		Melamine: <30% removal after 14 days with activated sludge (Measured)	IUCLID, 2000a	

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Melamine: <20% removal after 20 days, 14% removal after 10 days with adapted inoculum (Measured)	IUCLID, 2000a	
		Study results: 100%/<10 days Test method: Other: Pure culture study Bacterium, <i>Nocardioides</i> sp. strain ATD6 rapidly degraded melamine and accumulated cyanuric acid and ammonium, via the intermediates ammeline and ammelide. (Measured)	Takagi et al., 2012	Melamine degradation was found to occur in species specific biodegradation studies.
	Volatilization Half-life for Model River	Melamine polyphosphate: >1 year (Estimated)	EPI	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	Melamine polyphosphate: >1 year (Estimated)	EPI	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation	Melamine: Not readily biodegradable: 0% biodegradation detected after 2 weeks with 100 ppm in 30 ppm activated sludge (OECD TG 301C) (Measured); 0% degradation after 28 days with 100 mg DOC/L in activated sludge (Zahn-Wellens test, OECD 302B) (Measured)	MITI, 1998; OECD SIDS, 1999	Adequate values from guideline studies for the dissociated component, melamine.
		Study results: 100%/4 days Test method: Other: Pure culture study Bacterium, <i>A. citrulli</i> strain B-12227 rapidly degraded melamine and accumulated cyanuric acid, ammeline and ammelide, via the intermediates ammeline and ammelide. (Measured)	Shiomi and Ako, 2012	Melamine degradation was found to occur in species specific biodegradation studies.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		A set of soil bacteria has been identified whose members rapidly metabolize melamine as their source of nitrogen to support growth; these bacteria contain an enzyme which hydrolytically deaminate melamine (Measured)	Cook and Hutter, 1984; Cook and Hutter, 1981	Melamine degradation was found to occur in species specific biodegradation studies.
	Anaerobic Biodegradation	Melamine: 0-8.9% nitrification was observed after 28 days incubation with bacteria in Webster silty clay loam under anaerobic conditions (Measured)	IUCLID, 2000a	This value is for the dissociated component, melamine. Reported in a secondary source, study details and test conditions were not provided.
	Soil Biodegradation w/ Product Identification	Melamine: Nitrification of melamine occurs in soil at a low rate (0.7% organic N found as NO ₃ -N in week 10, and 0% in week 28). (Measured)	ECHA, 2011a, 2011b	Nonguideline studies for the dissociated component, melamine.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	Melamine polyphosphate: 21 days (Estimated)	EPI	
Reactivity	Photolysis	Melamine polyphosphate: Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	Polyphosphoric acid: The half-life for the hydrolysis to phosphoric acid is several days at 25°C (Measured)	Kirk-Othmer, 2005	This value is for the dissociated component, polyphosphoric acid. These studies indicate polyphosphoric acid would undergo hydrolysis under environmental conditions to phosphate ions. Reported in a secondary source, study details and test conditions were not provided.

Melamine Polyphosphate CASRN 15541-60-3				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Polyphosphoric acid: Hydrolysis occurs in 2 months at 20°C (Measured)	IUCLID, 2000b	This value is for the dissociated component, polyphosphoric acid. Reported in a secondary source, study details and test conditions were not provided available.
Environmental Half-life		Melamine polyphosphate: 120 days (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.
Bioaccumulation		LOW: Based on the relatively high water solubility of melamine polyphosphate (20 g/L) and an estimated BCF of 3.2. In addition, the experimental bioconcentration values for the melamine component are low, BCF <3.8, and estimated BAF <1.		
	Fish BCF	Melamine polyphosphate: 3.2 (Estimated)	EPI	
		Melamine: <0.38 in carp (<i>Cyprinus carpio</i>) after 6 weeks at 2.0 ppm concentration; <3.8 in carp (<i>Cyprinus carpio</i>) after 6 weeks at 0.2 ppm concentration (OECD 302B) (Measured)	MITI, 1998	Adequate values from guideline studies for the dissociated component, melamine.
	BAF	Melamine polyphosphate: 0.9 (Estimated)	EPI	
		Melamine: <1 (Measured)	OECD SIDS, 1999; IUCLID, 2000a	This value is for the dissociated component, melamine.
	Metabolism in Fish	Melamine: Uptake, bioaccumulation and elimination study with ¹⁴ C-melamine in fathead minnow and rainbow trout: BCFs <1 (Measured)	ECHA, 2011a, 2011b	Nonguideline studies that support the low potential for bioaccumulation of this substance.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		

Melamine Polyphosphate CASRN 15541-60-3

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Human Biomonitoring	This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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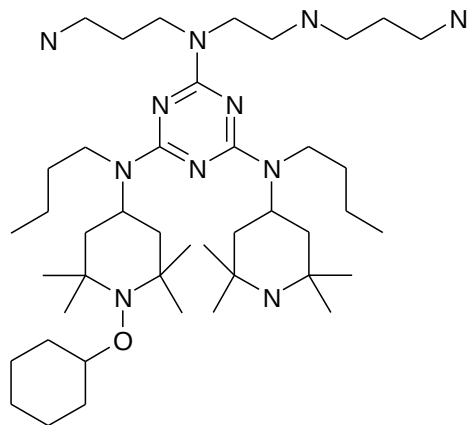
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment. [‡] The highest hazard designation of any of the oligomers with MW <1,000																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
N-alkoxy Hindered Amine Reaction Products	191680-81-6	L	M	L	H	H	L	H	L		L	VL	H	H	H	H [‡]

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

N-alkoxy Hindered Amine Reaction Products



Representative Structure

CASRN: 191680-81-6

MW: >1,300 (92%);
670-1,300 (3%);
<670 (5%)

MF:

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: N4C(N(CCNCCCN)CCCN)=NC(N(C2CC(C)(C)N(OC3CCCCC3)C(C)(C)C2)CCCC)=NC=4N(C1CC(C)(C)NC(C)(C)C1)CCCC (Representative Structure)

Synonyms: 1,3-Propanediamine, N1,N1'-1,2-ethanediylbis-, reaction products with cyclohexane and peroxidized N-butyl-2,2,6,6-tetramethyl-4-piperidinamine-2,4,6-trichloro-1,3,5-triazine reaction products; Flamestab Nor 116

Chemical Considerations: This alternative is a polymer. The structure shown is the simplest depiction of an oligomer with a MW <1,000 (approximately 770) that includes all combinations of monomers. This review assesses oligomers with a MW <1,000 using a representative structure. The representative structure lies within the domain of the available estimation methods. EPI v4.0 estimation methods were used for physical/chemical and environmental fate values in the absence of experimental data. The higher MW oligomers with a MW >1,000 are assessed together using information contained in the literature concerning polymer assessment and professional judgment (Boethling et al., 1997).

Polymeric: Yes	
Oligomers: The MF and MW of this polymer are variable; approximately 90% of the oligomers in this polymer have a MW >1,300 (NICNAS, 2001). The mixture is based on a substituted aliphatic tetra amine, where the substituents on the amine groups are variable. The presence of material in the commercial product with a MW <670 is likely the result of unchanged starting materials.	
Metabolites, Degradates and Transformation Products: None	
Analog: No analog Endpoint(s) using analog values: Not applicable	Analog Structure: Not applicable
Structural Alerts: Hindered amines (EPA, 2010)	
Risk Phrases: Not classified by Annex VI Regulation (European Commission) No 1272/2008 (ESIS, 2011).	
Hazard and Risk Assessments: This polymer has been assessed by NICNAS (NICNAS, 2001).	

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	113–121 softening point (Measured)	Ciba Additives, 1997a	Value is a result from differential scanning calorimetry analysis on the commercial product, with a reported endotherm trough at 120.43°C. The value of 113°C likely corresponds to a softening point for the polymer.
Boiling Point (°C)	Decomposes (Measured)	Ciba Additives, 1997b	The commercial product was found to decompose without boiling at 260°C at a reduced pressure of 6 kPa.
	>300 (Estimated)	EPI; EPA, 1999	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. Cutoff value according to High Production Volume (HPV) assessment guidance.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	EPI; EPA, 1999	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. Cutoff value according to HPV polymer assessment guidance.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	EPI; EPA, 1999	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. Cutoff value according to HPV assessment guidance.
Log K_{ow}	10 (Estimated)	EPI; EPA, 1999	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. Estimated value is greater than the cutoff value, >10, according to methodology based on HPV assessment guidance.

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N-alkoxy Hindered Amine Reaction Products CASRN 191680-81-6				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Flammability (Flash Point)		>110°C (Measured)	NICNAS, 2001	Sufficient details were not available to assess the quality of this study.
Explosivity		Not explosive European Economic Community method A.14 (Measured)	NICNAS, 2001	Adequate; guideline study.
Pyrolysis				No data located.
pH				No data located.
pK _a		2.4 to 10.2 (Estimated)	NICNAS, 2001	Inadequate. Compound only contains basic functional groups.
HUMAN HEALTH EFFECTS				
Toxicokinetics		As a neat material, N-alkoxy hindered amine reaction products is estimated to not be absorbed by any route of exposure. This compound is expected to have poor absorption through all routes when in solution. This material is predominately a polymer with a MW >1,000 however at present there is no MW cutoff for the hindered amine category of new chemicals (EPA, 2010b).		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Not absorbed by any route as a neat material; poor absorption for all routes when in solution	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
Acute Mammalian Toxicity		LOW: Based on an acute oral LD₅₀ >5,000 mg/kg and an acute dermal LD₅₀ >2,000 mg/kg for rats.		
Acute Lethality	Oral	Rat Oral LD ₅₀ >5,000 mg/kg bw	NICNAS, 2001	Reported in a secondary source. Guideline study (Organisation of Economic Cooperation and Development (OECD) 401, limit test).
	Dermal	Rat Dermal LD ₅₀ >2,000 mg/kg bw	NICNAS, 2001	Reported in a secondary source. Guideline study (OECD 402, limit test).
	Inhalation			No data located.
Carcinogenicity		MODERATE: There is uncertainty due to lack of data for this substance. EPA does not expect this substance to be carcinogenic however such effects cannot be ruled out.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	OncoLogic Results			This polymer is not amenable to available estimation methods.
	Carcinogenicity (Rat and Mouse)			No data located.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		LOW: N-alkoxy hindered amine reaction products did not induce gene mutations in <i>Salmonella typhimurium</i> or <i>Escherichia coli</i> and did not induce chromosomal aberrations in Chinese hamster ovary (CHO) cells in the presence and absence of metabolic activation.		
	Gene Mutation <i>in vitro</i>	Negative for gene mutations in <i>Salmonella typhimurium</i> strains TA1535, TA1537, TA98, TA100 and <i>E. coli</i> strain WP2uvrA with and without metabolic activation.	NICNAS, 2001	Reported in a secondary source. Guideline study (OECD 471, bacterial reverse mutation test).
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative for chromosomal aberrations in CHO cells with and without metabolic activation. No evidence of clastogenicity.	NICNAS, 2001	Reported in a secondary source. Guideline study (OECD 473, <i>in vitro</i> mammalian chromosomal aberration test).
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		HIGH: Estimated potential for reproductive effects based on analogy to other hindered amines similar in structure.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects	Toxicity to male reproductive system (Estimated by analogy)	Professional judgment, Toxic Substances Control Act (TSCA) New Chemicals Program – Chemical Categories	Estimated based on analogy to hindered amines similar in structure.
Developmental Effects		HIGH: Estimated potential for developmental effects based on analogy to other hindered amines similar in structure.		
	Reproduction/ Developmental Toxicity Screen	Delayed skeletal maturation LOAEL = 1,200 mg/kg/day (Estimated by analogy)	Professional judgment	Estimated based on analogy to hindered amines similar in structure.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development			No data located.
	Postnatal Development			No data located.
Neurotoxicity		LOW: Estimated not to have potential for neurotoxicity based on expert judgment. No data located.		
	Neurotoxicity Screening Battery (Adult)	No potential for neurotoxicity (Estimated)	Expert judgment	Estimated based on expert judgment.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects		HIGH: Estimated potential for repeated dose effects based on analogy to other hindered amines similar in structure. Experimental data reported that N-alkoxy hindered amine reaction products did not produce adverse effects in a 28-day oral gavage study in rats at oral doses up to 1,000 mg/kg/day; however uncertainty remains for exposures of longer duration.		
		Toxicity to liver, blood, and gastrointestinal tract (Estimated by analogy)	Professional judgment, TSCA New Chemicals Program – Chemical Categories	Estimated based on analogy hindered amines similar in structure.
		28-day oral gavage study in Sprague-Dawley rats. No treatment-related clinical effects or changes in clinical chemistry, hematology, urinalysis or organ weight. NOAEL = 1,000 mg/kg/day LOAEL = not established as highest dose tested did not produce adverse effects	NICNAS, 2001	Reported in a secondary source. Guideline study (OECD 407). The hindered amines category suggests need for a 90-day oral test.
	Immune System Effects	Effects on thymus, spleen, lymph and nodes (Estimated by analogy)	Professional judgment, TSCA New Chemicals Program – Chemical Categories	Estimated based on analogy hindered amines similar in structure.
Skin Sensitization		LOW: N-alkoxy hindered amine reaction products did not produce skin sensitization in an experimental study in guinea pigs.		
	Skin Sensitization	No evidence of sensitization, guinea pig	NICNAS, 2001	Reported in a secondary source. Guideline study (OECD 406).
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: N-alkoxy hindered amine reaction products are slightly irritating to rabbit eyes with clearing within 24 hours.		
	Eye Irritation	Slightly irritating, rabbit. Most symptoms cleared in 24 hours or less. Redness persisted for 48 hours.	NICNAS, 2001	Reported in a secondary source. Guideline study (OECD 405, acute eye irritation/corrosion).

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Dermal Irritation		VERY LOW: N-alkoxy hindered amine reaction products are not irritating to rabbit skin.		
	Dermal Irritation	Non-irritating, rabbit	NICNAS, 2001	Reported in a secondary source. Guideline study (OECD 404, acute dermal irritation/corrosion).
Endocrine Activity		No data located.		
				No data located.
Immunotoxicity		Estimated potential for immunotoxic effects based on analogy to other hindered amines similar in structure.		
	Immune System Effects	Effects on thymus, spleen, lymph and nodes (Estimated by analogy)	Professional judgment, TSCA New Chemicals Program – Chemical Categories	Estimated based on analogy hindered amines similar in structure.
ECOTOXICITY				
ECOSAR Class		Polycationic Polymers; Aliphatic Amines; Triazines		
Acute Toxicity		HIGH: Based on estimated acute aquatic toxicity values for fish, daphnid, and green algae using polycationic polymer SAR.		
Fish LC₅₀		<i>Pimephales promelas</i> 96-hour LC ₅₀ >0.268 mg/L, NOEC = 0.268 mg/L (48-hour static-renewal, mean measured) (OECD TG 203) (Experimental)	NICNAS, 2001	Reported in a secondary source. Guideline study; reported values are greater than the water solubility; no effects at saturation (NES) were observed for this endpoint.
		Fish 96-hour LC ₅₀ = 0.280 mg/L (Estimated)	Professional judgment	Predictions based on SARs for polycationic polymers with >3.5% amine-N.
		Fish 96-hour LC ₅₀ = 0.0015 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 6.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish 96-hour LC ₅₀ = 3.28 x10 ⁻⁸ mg/L (Estimated) ECOSAR: Triazines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 5.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.
	Fish 96-hour LC ₅₀ = 6.56 x10 ⁻⁵ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 5.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid LC₅₀	Daphnia 48-hour EC ₅₀ >0.312 mg/L, NOEC = 0.312 mg/L (24- hour static-renewal, mean measured) (OECD TG 202) (Experimental)	NICNAS, 2001	Reported in a secondary source. Guideline study; reported values are greater than the water solubility; NES were observed for this endpoint.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnid 48-hour LC ₅₀ = 0.1 mg/L (Estimated)	Professional judgment	Predictions based on SARs for polycationic polymers with >3.5% amine-N.
	Daphnid 48-hour LC ₅₀ = 0.000846 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 5.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.
	Daphnid 48-hour LC ₅₀ = 1.05 x10 ⁻⁵ mg/L (Estimated) ECOSAR: Triazines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 5.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.

N-alkoxy Hindered Amine Reaction Products CASRN 191680-81-6

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnid 48-hour LC ₅₀ = 1.05x10 ⁻⁵ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 5.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Green Algae EC ₅₀	Green Algae (<i>Pseudokirchneriella subcapitata</i>) 72-hour EbC ₅₀ >0.083 mg/L, NOEC = 0.083 mg/L (static, measured at study termination) (OECD TG 201) (Experimental)	NICNAS, 2001	Reported in a secondary source. Guideline study; reported values are greater than the water solubility; NES were observed for this endpoint.
	Green algae 96-hour EC ₅₀ = 0.04 mg/L (Estimated)	Professional judgment	Predictions based on SARs for polycationic polymers with >3.5% amine-N.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae 96-hour LC ₅₀ = 0.005 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 7.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.
	Green algae 96-hour LC ₅₀ = 0.000657 mg/L (Estimated) ECOSAR: Triazines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 6.4; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae 96-hour LC ₅₀ = 1.05x10 ⁻⁵ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 6.4; NES are predicted for these endpoints. The higher oligomers outside the domain of the estimation method are anticipated to display NES. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Chronic Aquatic Toxicity	HIGH: Based on estimated chronic aquatic toxicity values for fish, daphnid, and green algae using polycationic polymer SARs.		
Fish ChV	Fish ChV = 0.016 mg/L (Estimated)	Professional judgment	Predictions based on SARs for polycationic polymers with >3.5% amine-N.
	ChV = 5.31x10 ⁻⁵ mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the structure activity relationship (SAR) limitation of 8.0; NES are predicted for these endpoints. The higher oligomers outside the domain of the estimation method are anticipated to display NES.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish ChV = 5.19×10^{-6} mg/L (Estimated) ECOSAR: Triazines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 8.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.
	Fish ChV = 5.19×10^{-6} mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 8.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

N-alkoxy Hindered Amine Reaction Products CASRN 191680-81-6

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid ChV	ChV = 0.014 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 8.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.
	ChV = 4.67x10 ⁻⁵ mg/L (Estimated) ECOSAR: Triazines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 8.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.

N-alkoxy Hindered Amine Reaction Products CASRN 191680-81-6

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	ChV = 4.04×10^{-5} (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 8.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	ChV = 0.007 mg/L (Estimated)	Professional judgment	Predictions based on SARs for polycationic polymers with >3.5% amine-N.
Saltwater Invertebrate ChV	ChV = 0.014 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 8.0; NES are predicted for these endpoints The higher oligomers outside the domain of the estimation method are anticipated to display NES.

N-alkoxy Hindered Amine Reaction Products CASRN 191680-81-6

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Green Algae ChV	ChV = 0.000234 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 7.0; NES are predicted for these endpoints. The higher oligomers outside the domain of the estimation method are anticipated to display NES.
	ChV = 0.002 mg/L (Estimated) ECOSAR: Triazines	ECOSAR version 1.11	NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 7.0; NES are predicted for these endpoints. The higher oligomers outside the domain of the estimation method are anticipated to display NES.

N-alkoxy Hindered Amine Reaction Products CASRN 191680-81-6

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	ChV = 0.002 mg/L (Estimated) ECOSAR: Neutral organics		NES: Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. The log K _{ow} of 10 for this chemical exceeds the SAR limitation of 8.0; NES are predicted for these endpoints. The higher oligomers outside the domain of the estimation method are anticipated to display NES. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	ChV = 0.02 mg/L (Estimated)	Professional judgment	Predictions based on SARs for polycationic polymers with >3.5% amine-N.
ENVIRONMENTAL FATE			
Transport	Based on the Level III fugacity models incorporating the available property data, N-alkoxy hindered amine reaction products are expected to partition primarily to soil and sediment. This compound is expected to be immobile in soil based on its estimated K _{oc} . Leaching of N-alkoxy hindered amine reaction products through soil to groundwater is not expected to be an important transport mechanism. Estimated volatilization half-lives indicate that it will be non-volatile from surface water. Volatilization from dry surface is also not expected based on its vapor pressure. In the atmosphere, this compound is expected to exist solely in the particulate phase, based on its estimated vapor pressure. Particulates may be removed from air by wet or dry deposition.		

N-alkoxy Hindered Amine Reaction Products CASRN 191680-81-6

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Henry's Law Constant (atm-m³/mole)	<10 ⁻⁸ (Estimated)	EPI; Professional judgment	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. Cutoff value for nonvolatile compounds.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated)	EPI; EPA, 2004	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers. Cutoff value for non-mobile compounds.
	Level III Fugacity Model	Air: <1% (Estimated) Water: <1% Soil = 53% Sediment = 47%	EPI	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers.
Persistence		HIGH: The persistence for N-alkoxy hindered amine reaction products is based on an experimental guideline biodegradation study (4% removal after 28 days). Although a biodegradation half-life was not calculated based on this study, it indicates that biodegradation of N-alkoxy hindered amine reaction products is possible under the stringent test conditions. Approximately 90% of the commercial N-alkoxy hindered amine reaction products substance has a MW >1,300 and is not anticipated to be assimilated by microorganisms. This polymer is not expected to be removed by other degradative processes under environmental conditions, such as hydrolysis, since it lacks the functional groups that hydrolyze under environmental conditions. This polymer does not contain chromophores that absorb at wavelengths >290 nm, and therefore it is not expected to be susceptible to direct photolysis by sunlight. The atmospheric half-life is estimated to be 19 minutes, although it is expected to exist primarily in the particulate phase in air.		
Water	Aerobic Biodegradation	Ready Test: Modified Sturm Test (OECD TG 301B); 4.37% biodegradation detected after 28 days in sewage sludge (Measured)	Toxicon, 1997	Adequate, guideline study.
	Volatilization Half-life for Model River	>1 year (Estimated)	EPI	
	Volatilization Half-life for Model Lake	>1 year (Estimated)	EPI	
Soil	Aerobic Biodegradation			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Anaerobic Biodegradation	Not probable (Anaerobic-methanogenic biodegradation probability model) (Estimated)	EPI	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	19 minutes (Estimated)	EPI	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	Not a significant fate process (Estimated)	Wolfe and Jeffers, 2000; Professional judgment	The substance does not contain functional groups that would be expected to hydrolyze readily under environmental conditions.
Environmental Half-Life		>180 days (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology, for a representative oligomer with a MW <1,000.
Bioaccumulation		HIGH: A representative oligomer (with MW 770) that includes all combinations of monomers has an estimated BAF of 2,300; this BAF value, which accounts for metabolism, suggests that this substance has potential to bioaccumulate in higher trophic levels.		
	Fish BCF	27 (Estimated)	EPI	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	BAF	2,300 (Estimated)	EPI	Estimate based on a representative oligomer with a MW <1,000 that includes all monomers.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Wolfe, N.; Jeffers, P. (2000) Hydrolysis. In Boethling, R.; Mackay, D., *Handbook of Property Estimation Methods for Chemicals*, Environmental Health Sciences (311-334). Boca Raton: Lewis Publishers.

Phosphonate Oligomer

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

[§] Based on analogy to experimental data for a structurally similar compound.

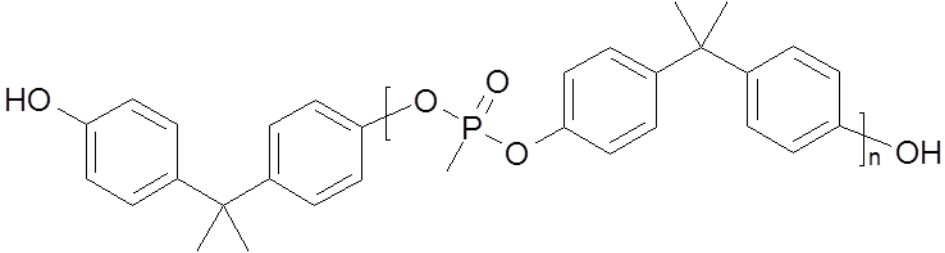
[‡] The highest hazard designation of any of the oligomers with MW <1,000.

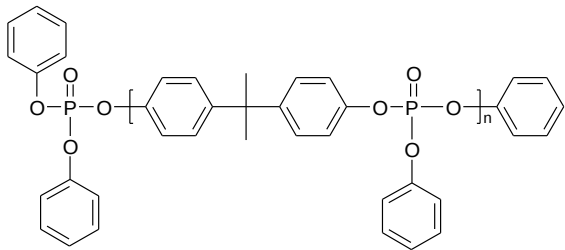
[¥] Phosphonate Oligomer, with a MW range of 1,000 to 5,000, may contain significant amounts of an impurity, depending on the final product preparation. This impurity has hazard designations that differ from the polymeric flame retardant, as follows: MODERATE (experimental) designation for carcinogenicity, reproductive and repeated dose toxicity, skin sensitization, eye and dermal irritation; and HIGH (experimental) designation for developmental toxicity and acute & chronic aquatic toxicity.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Phosphonate Oligomer [¥]	68664-06-2	L	M	L[§]	L[¥]	L[¥]	M[‡]	L^{§¥}	L^{§¥}		M^{‡¥}	M[‡]	L[¥]	H[‡]	VH	H[‡]

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Phosphonate Oligomer

	CASRN: 68664-06-2
	MW: 1,000-5,000; 25% MW <1,000
	MF: C ₁₅ H ₁₆ O ₂ (C ₁₆ H ₁₇ O ₃ P) _n C ₃₁ H ₃₃ O ₅ P (n = 1); C ₄₇ H ₅₀ O ₈ P ₂ (n = 2)
	Physical Forms: Solid
	Use: Flame retardant
Representative Structure	
SMILES: The polymer components with MW >1,000 are not amenable to SMILES notation. Phosphonate Oligomer: c1(O)ccc(C(C)(C)c2ccc(OP(C)(=O)Oc3ccccc3)cc2)cc1 (n=0; MW = 382); c1(O)ccc(C(C)(C)c2ccc(OP(C)(=O)Oc3ccc(C(C)(C)c4ccc(O)cc4)cc3)cc2)cc1 (representative structure for n = 1; MW = 516); c1(O)ccc(C(C)(C)c2ccc(OP(C)(=O)Oc3ccc(C(C)(C)c4ccc(OP(C)(=O)Oc5ccc(C(C)(C)c6ccc(O)cc6)cc5)cc4)cc3)cc2)cc1 (representative structure for n = 2, MW = 805); impurity: confidential SMILES.	
Synonyms: Nofia® oligomers; FRX Oligomers (phosphonate oligomers); Phosphonic acid, P-methyl-, diphenyl ester, polymer with 4,4'-(1-methylethylidene)bis[phenol] (not a copolymer)	
Chemical Considerations: This alternative is a polymer consisting of a large portion of higher (>1,000) MW oligomers and a smaller portion of lower (<1,000) MW oligomers. The higher MW oligomers, with a MW >1,000, are assessed together using information contained in the literature concerning polymer assessment and professional judgment (Boethling et al., 1997). The n=1 and n=2 oligomers are those with a MW <1,000 and are assessed with EPI v4.1 due to an absence of experimental physical/chemical, environmental fate and aquatic toxicity values. Multiple n=1 and n=2 oligomer structures are possible from various starting material combinations. A representative structure was selected for determining the estimated n=1 and n=2 values, as identified in the SMILES section above. The human health designations for the lower MW oligomers are a result of identified structural alerts and experimental data from analogous compounds. Additionally, a confidential impurity may be present in polymer. The overall hazard designation for each endpoint represents the most conservative value of the higher MW oligomers and lower MW oligomers. A summary of the hazards of the confidential impurity is provided in hazard summary table as a footnote (¶).	

Polymeric: Yes Oligomers: The polymers are produced from the trans-esterification of methyldiphenylphosphonate and bisphenol A. The MW of Phosphonate Oligomer ranges between 1,000 and 5,000. Oligomers with MW <1,000 are expected to be present in 25% of the Phosphonate Oligomer formulation.	
Metabolites, Degradates and Transformation Products: None	
Analog: BAPP (181028-79-5) Endpoint(s) using analog values: Genotoxicity; skin sensitization; repeated dose	Analog Structure:  BAPP (181028-79-5)
Structural Alerts: Phenols, neurotoxicity (EPA, 2010).	
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).	
Hazard and Risk Assessments: None identified.	

Phosphonate Oligomer CASRN 68664-06-2			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	90 softening point (Measured)	FRX Polymers, Inc., 2009	The value corresponds to a softening point for the polymer.
Boiling Point (°C)	>300 (Estimated for n ≥ 3 oligomers)	Professional judgment	Cutoff value used for large, high MW solid.
	>300 (Estimated for n=1; n=2 oligomers)	EPI; EPA, 1999	Cutoff value for high boiling point compounds according to High Production Volume (HPV) assessment guidance.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated for n ≥ 3 oligomers)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW polymers.
	<10 ⁻⁸ (Estimated for n=1; n=2 oligomers)	EPI; EPA, 1999	Cutoff value for nonvolatile compounds according to HPV assessment guidance.
Water Solubility (mg/L)	<10 ⁻³ (Estimated for n ≥ 3 oligomers)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
	0.0015 (Estimated for n=1)	EPI	
	<10 ⁻³ (Estimated for n=2)	EPI; EPA, 1999	Cutoff value for non soluble compounds according to HPV assessment guidance.
Log K_{ow}	No data located for n ≥ 3 oligomers	Professional judgment	This polymer is not amenable to available estimation methods.
	7.2 (Estimated for n=1)	EPI	
	11 (Estimated for n=2)	EPI; EPA, 1999	Estimated value is greater than the cutoff value, >10, according to methodology based on HPV assessment guidance.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.

Phosphonate Oligomer CASRN 68664-06-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Explosivity		Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis				No data located.
pH		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
HUMAN HEALTH EFFECTS				
Toxicokinetics		No absorption is expected for any route of exposure for the neat material of Phosphonate Oligomer. The lower MW fraction, in solution, is predicted to have poor absorption for all routes. The higher MW oligomers are large, with a MW >1,000. Based on professional judgment, Phosphonate Oligomer is expected to have limited bioavailability and therefore is not expected to be readily absorbed, distributed or metabolized in the body.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption of Phosphonate Oligomer is expected for any route; poor absorption of the low MW fraction when in solution is expected for all routes. (Estimated)	Professional judgment	Estimated based on physical/chemical properties and limited bioavailability.
Acute Mammalian Toxicity		LOW: Based on experimental LD ₅₀ values of >2,000 mg/kg. The majority of this polymer consists of high MW oligomers. Thus, this compound is also expected to have limited bioavailability and therefore has low potential for acute mammalian toxicity.		
	Oral	Rat oral LD ₅₀ >2,000 mg/kg	FRX Polymers, Inc., 2010	Conducted according to Organisation of Economic Cooperation and Development (OECD) 420; test substance: FRX oligophosphonate.
	Dermal Inhalation	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.

Phosphonate Oligomer CASRN 68664-06-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Carcinogenicity		MODERATE: There is uncertainty for Phosphonate Oligomer due to the lack of data for this substance. Carcinogenic effects cannot be ruled out.		
	OncoLogic Results			This polymer is not amenable to available estimation methods.
	Carcinogenicity (Rat and Mouse)			No data located.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		LOW: Estimated for Phosphonate Oligomer based on analogy to BAPP (181028-79-5).		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected for the high MW (>1,000) components. (Estimated)	Professional judgment; Boethling et al., 1997	Based on polymer assessment literature.
		Negative, Ames assay (standard plate) in <i>Salmonella typhimurium</i> strains TA98, TA100, TA1537, TA1535, and <i>E. coli</i> WP2uvrA with and without metabolic activation. (Estimated by analogy)	NICNAS NA/869, 2000; Professional judgment	Based on analogy to BAPP; Sufficient study details were reported in a secondary source; used OECD test guidelines (OECD 471 & 472). Data are for commercial mixture of BAPP.
		Negative, Ames assay (standard plate) in <i>Salmonella typhimurium</i> strains TA98, TA100, TA1537, TA1535, and <i>E. coli</i> WP2uvrA with and without metabolic activation. (Estimated by analogy)	NICNAS NA/773, 2000; Professional judgment	Based on analogy to BAPP. Sufficient study details were reported in a secondary source; used OECD test guidelines (OECD 471 & 472). Data are for the predominant component of BAPP.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative for chromosome aberrations in Chinese hamster lung (CHL)/IU cells with and without metabolic activation.	FRX Polymers, Inc, 2011c	Conducted in compliance with good laboratory practice.

Phosphonate Oligomer CASRN 68664-06-2

Phosphonate Oligomer CASRN 68664-06-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Negative, did not produce chromosomal aberrations in CHO cells with and without metabolic activation. (Estimated by analogy)	NICNAS NA/869, 2000; Professional judgment	Based on analogy to BAPP. Sufficient study details were reported in a secondary source; used OECD test guidelines (OECD 473). Data are for commercial mixture of BAPP.
		Negative, did not produce chromosomal aberrations in CHL cells with and without metabolic activation. (Estimated by analogy)	NICNAS NA/773, 2000; Professional judgment	Based on analogy to BAPP. Sufficient study details were reported in a secondary source; used EC/European Economic Community (EEC) test guidelines (EC Directives 87/18/EEC and 88/320/EEC). Data are for the predominant component of BAPP.
	Chromosomal Aberrations <i>in vivo</i>	Negative; did not increase micronucleated polychromatic erythrocytes in bone marrow cells of mice. (Estimated by analogy)	NICNAS NA/869, 2000; Professional judgment	Based on analogy to BAPP. Sufficient study details were reported in a secondary source; used OECD test guidelines (OECD 474). Data are for commercial mixture of BAPP.
	DNA Damage and Repair			No data located.
	Other			No data located.
Reproductive Effects		LOW: The high MW components of Phosphonate Oligomer are expected to have limited bioavailability and therefore have low potential for reproductive effects based on professional judgment and the polymer assessment literature. No structural alerts or mechanistic pathways associated with reproductive effects were identified for the lower MW oligomeric material (n=1 and n=2).		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected. (Estimated for n ≥3 oligomers)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.
		No data located (For n=1 and n=2 oligomers)	Professional judgment	No structural alerts or mechanistic pathways associated with reproductive effects were identified for the lower MW oligomeric material.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected. (Estimated for n≥3 oligomers)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.
		No data located (For n=1 and n=2 oligomers)	Professional judgment	No structural alerts or mechanistic pathways associated with reproductive effects were identified for the lower MW oligomeric material.
	Reproduction and Fertility Effects	Limited bioavailability expected. (Estimated for n ≥3 oligomers)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.
		No data located (For n=1 and n=2 oligomers)	Professional judgment	No structural alerts or mechanistic pathways associated with reproductive effects were identified for the lower MW oligomeric material.
Developmental Effects		LOW: The high MW polymeric material is expected to have limited bioavailability and therefore has low potential for developmental effects based on professional judgment and the polymer assessment literature. No structural alerts or mechanistic pathways associated with developmental effects were identified for the lower MW oligomeric material (n=1 and n=2).		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected. (Estimated for n≥3 oligomers)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.
		No data located (Estimated for n=1 and n=2 oligomers)	Professional judgment	No structural alerts or mechanistic pathways associated with reproductive effects were identified for the lower MW oligomeric material.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected. (Estimated for n≥3 oligomers)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.
		No data located (Estimated for n=1 and n=2 oligomers)	Professional judgment	No structural alerts or mechanistic pathways associated with reproductive effects were identified for the lower MW oligomeric material.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Neurotoxicity		MODERATE: A moderate hazard is estimated for the Phosphonate Oligomer. There is potential for neurotoxicity based on the presence of the phenol structural alert.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected. (Estimated for n≥3 oligomers)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.
	Other	Potential for neurotoxic effects based on a structural alert for organophosphates (Estimated by analogy)	Professional Judgment	Estimated based on a structural alert for organophosphates and professional judgment.
Repeated Dose Effects		LOW: A low hazard is estimated for the lower MW oligomers of Phosphonate Oligomer based on analogy to BAPP (181028-79-5), which has a low hazard potential for this endpoint. The hazard designation for oligomers with n ≥3 is also of low hazard potential based on limited bioavailability.		
		Limited bioavailability expected. (Estimated for n≥3 oligomers)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.
		In a 28-day oral (gavage) study in Sprague-Dawley rats, there were no treatment-related changes in any of the parameters measured. NOEL ≥1,000 mg/kg-day (highest dose tested) (Estimated by analogy)	NICNAS NA/869, 2000; Professional judgment	Based on analogy to BAPP. Sufficient study details were reported; used OECD test guidelines (OECD 407). Data are for commercial mixture of BAPP.
		In a 28-day oral (gavage) study in Sprague-Dawley rats, there were no treatment-related changes in any of the parameters measured NOEL ≥1,000 mg/kg-day (highest dose tested). (Estimated by analogy)	NICNAS NA/773, 2000; Professional judgment	Based on analogy to BAPP. Sufficient study details were reported; used EEC test guidelines (EEC Directive 92/69/EEC, Method B7). Data are for the predominant component of BAPP.
Skin Sensitization		LOW: Based on expert judgment, Phosphonate Oligomer is not estimated to have potential for skin sensitization. No experimental data were located for this compound. For the lower MW oligomers, the hazard designation is low based on analogy to BAPP (181028-79-5).		
	Skin Sensitization	Not expected to be a skin sensitizer (Estimated for n≥3 oligomers)	Expert judgment	Estimated based on expert judgment.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Non-sensitizing, guinea pig (Estimated by analogy)	NICNAS NA/869, 2000; Professional judgment	Based on analogy to BAPP. Conducted according to EEC/OECD guidelines (OECD 406). Data are for commercial mixture of BAPP.
		Non-sensitizing, guinea pig (Estimated by analogy)	NICNAS NA/773, 2000; Professional judgment	Based on analogy to BAPP. Conducted according to EEC/OECD guidelines (OECD 406). Data are for the predominant component of BAPP.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		MODERATE: There is potential for irritation for Phosphonate Oligomer based on the phenol moieties.		
	Eye Irritation	Uncertain potential for irritation based on the phenol moieties. (Estimated)	Professional judgment	Estimated based on phenol moieties.
Dermal Irritation		MODERATE: There is potential for irritation for Phosphonate Oligomer based on the phenol moieties structural alert.		
	Dermal Irritation	Uncertain potential for irritation based on the phenol moieties. (Estimated)	Professional judgment	Estimated based on phenol moieties.
Endocrine Activity		Based on expert judgment; Phosphonate Oligomer is not expected to have endocrine activity due to its poor bioavailability and inability to be readily metabolized in the body.		
		Limited bioavailability expected. (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.
Immunotoxicity		Based on expert judgment; Phosphonate Oligomer is expected to have limited bioavailability and therefore has low potential for hazard.		
	Immune System Effects	Limited bioavailability expected. (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff value for large, high MW non-ionic polymers.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ECOTOXICITY			
ECOSAR Class	Not applicable for n≥3 oligomers. Polyphenols for n=1 and n=2.		
Acute Toxicity	LOW: Estimated data for Phosphonate Oligomer suggest no effects at saturation (NES) for the acute aquatic toxicity endpoints for the n=1 and n=2 oligomers and the non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are estimated to have NES. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Bioavailability is limited because this chemical cannot be absorbed through membranes due to large size.		
Fish LC₅₀	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
	Fish 96-hour LC ₅₀ = 0.022 mg/L (Estimated for n=1) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 7.2 for this chemical exceeds the SAR limitation for log K _{ow} of 5.5; NES are predicted for these endpoints.
	Fish 96-hour LC ₅₀ = 0.009 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 7.2 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish 96-hour LC ₅₀ = 0.00026 mg/L (Estimated for n=2) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 5.5; NES are predicted for these endpoints.
	Fish 96-hour LC ₅₀ = 0.0000087 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Daphnid LC₅₀	<i>Daphnia magna</i> 48-hour EC ₅₀ >0.275 mg/L; semi static conditions. (Experimental)	FRX Polymers, Inc, 2011a	Study conducted according to guidelines for daphnia acute immobilization test; test substance purity = 96.39%. It is not clear if the reported value represents nominal or actual concentrations of dissolved species.
	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnid 48-hour LC ₅₀ = 0.022 mg/L (Estimated for n=1) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 7.2 for this chemical exceeds the SAR limitation for log K _{ow} of 5.5; NES are predicted for these endpoints.
	Daphnid 48-hour LC ₅₀ = 0.013 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 7.2 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Daphnid 48-hour LC ₅₀ = 0.000061 mg/L (Estimated for n=2) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 5.5; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnid 48-hour LC ₅₀ = 0.000024 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Green Algae EC₅₀	<i>Pseudokirchneriella subcapitata</i> 72-hour EC ₅₀ >0.124 mg/L (Experimental)	FRX Polymers, Inc, 2011b	Study conducted according to guidelines for algal growth inhibition test; test substance purity = 96.39%. It is not clear if the reported value represent nominal or actual concentrations of dissolved species.
	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
	Green algae 96-hour EC ₅₀ = 0.19 mg/L (Estimated for n=1) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 7.2 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae 96-hour EC ₅₀ = 0.012 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 7.2 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Green algae 96-hour EC ₅₀ = 0.018 mg/L (Estimated for n=2) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae 96-hour EC ₅₀ = 0.000024 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Chronic Aquatic Toxicity	HIGH: Based on estimated data for chronic aquatic toxicity endpoints for the n=1 and n=2 oligomers. It should be noted that the estimated values may be near the limit of the domain of applicability for this estimation model and there is a high degree of uncertainty in these estimated results.		
Fish ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
	Fish 30-day ChV = 0.005 mg/L (Estimated for n=1) ECOSAR: Phenols, Poly	ECOSAR version 1.11	The estimated value is close to the cutoff value of this ECOSAR class. There is a high degree of uncertainty as the estimates for this compound are at the limits of the domain for this estimation model.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish 30-day ChV = 0.0015 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	The estimated value is close to the cutoff value of this ECOSAR class. There is a high degree of uncertainty as the estimates for this compound are at the limits of the domain for this estimation model. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Fish 30-day ChV = 0.000037 mg/L (Estimated for n=2) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish 30-day ChV = 0.0000022 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Daphnid ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
	Daphnid Daphnid ChV = 0.006 mg/L (Estimated for n=1) ECOSAR: Phenols, Poly	ECOSAR version 1.11	The estimated value is close to the cutoff value of this ECOSAR class. There is a high degree of uncertainty as the estimates for this compound are at the limits of the domain for this estimation model.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnid Daphnid ChV = 0.003 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	The estimated value is close to the cutoff value of this ECOSAR class. There is a high degree of uncertainty as the estimates for this compound are at the limits of the domain for this estimation model. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Daphnid Daphnid ChV = 0.000013 mg/L (Estimated for n=2) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnid Daphnid ChV = 0.00001 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Green Algae ChV	NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
	Green algae ChV = 0.054 mg/L (Estimated for n=1) ECOSAR: Phenols, Poly	ECOSAR version 1.11	Chemical may not be soluble enough to measure this predicted effect; ChV value exceeds water solubility.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae ChV = 0.034 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	Chemical may not be soluble enough to measure this predicted effect; ChV value exceeds water solubility. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Green algae ChV = 0.009 mg/L (Estimated for n=2) ECOSAR: Phenols, Poly	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Green algae ChV = 0.00037 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 11 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that this polymer is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of <10 ⁻⁸ atm-m ³ /mole indicates that it is not expected to volatilize from water to the atmosphere. The estimated K _{oc} of >30,000 indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated for n≥3 oligomers)	Professional judgment; Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.
		<10 ⁻⁸ (Estimated for n=1 and n=2)	EPI; Professional judgment	Cutoff value for nonvolatile compounds.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated for n≥3 oligomers)	Professional judgment; Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to adsorb strongly to soil and sediment
		>30,000 (Estimated for n=1 and n=2)	EPI; EPA, 2004	Cutoff value for non-mobile compounds.
	Level III Fugacity Model	Air ≤1% Water <1% Soil = 53% Sediment = 46% (Estimated for n = 1 and n = 2)	EPI	No data located for the high MW component of the polymers.
Persistence		VERY HIGH: The high MW components (MW >1,000) of this polymer are expected to have negligible water solubility and poor bioavailability to microorganisms indicating that neither biodegradation nor hydrolysis are expected to be important removal processes in the environment. The polymer does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths. Evaluation of these degradation values suggest a half-life of >180 days.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated for n ≥3 oligomers)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.
		Weeks (Primary Survey Model) Recalcitrant (Ultimate Survey Model) for n=1 (Estimated)	EPI	
		Weeks-months (Primary Survey Model) Recalcitrant (Ultimate Survey Model) for n=2 (Estimated)	EPI	
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	This polymer is anticipated to be nonvolatile.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	This polymer is anticipated to be nonvolatile.
Soil	Aerobic Biodegradation	Recalcitrant (Estimated for n ≥3 oligomers)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Anaerobic Biodegradation	Recalcitrant (Estimated for $n \geq 3$ oligomers)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be resistant to removal under anoxic conditions due to their limited bioavailability.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.
Environmental Half-life		>180 days (Estimated)	Professional judgment	The majority of this substance has a MW >1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to be removed by other degradative processes under environmental conditions because of limited water solubility and limited partitioning to air.

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PROPERTY/ENDPOINT		DATA		REFERENCE	DATA QUALITY		
Bioaccumulation		HIGH: Although measured BCF values are available, estimated BAF values are incorporated for a conservative approach. The BAF estimates are consistent with the potential for bioaccumulation that is anticipated. The high MW oligomers do not contribute to the bioaccumulation designation. The high MW oligomers are expected to have poor bioavailability and are not expected to be bioaccumulative.					
	Fish BCF	Eight components of this polymer with MW <1,000 were tested according to “Bioconcentration test of chemical substances in fish and shellfish” in <i>Cyprinus carpio</i> . Test concentrations of 0.01 and 0.001 mg/L. Results:		FRX Polymers Inc., 2012		Reported as Japanese notification, guideline study.	
		Mass to charge ratio (m/z)	High Conc. Level BCF				Low Conc. Level BCF
		383	≤41				<222
		517	≤85				<223-242
		688	≤60				<142
		822	≤67	<114-280			
		976	≤53	<128			
		537	274	<200-560			
		577	82-250	<200-534			
		825	<20-52	<200			
		<100 (Estimated for n≥3 oligomers)		Professional judgment	The substance has a MW >1,000 and is not anticipated to be taken up by aquatic organisms; therefore, bioconcentration is not expected.		
		10,000 (Estimated for n=1)		EPI			
		190 (Estimated for n=2)		EPI			

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	BAF	For n ≥3 oligomers		No data located.
		780,000 (Estimated for n=1)	EPI	
		64,000 (Estimated for n=2)	EPI	
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol; BPBP

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

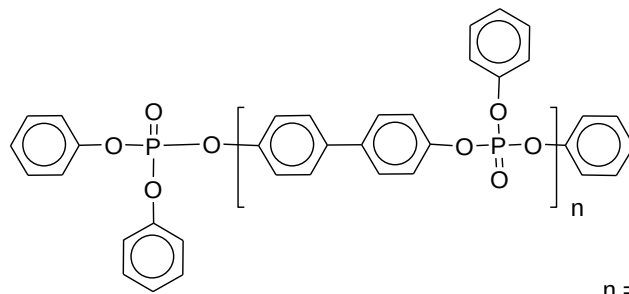
[‡] The highest hazard designation of any of the oligomers with MW <1,000.

[§] Based on analogy to experimental data for a structurally similar compound.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol; BPBP	1003300-73-9	L	M	L	L [§]	L [§]	L	L	L		VL	VL	H [§]	H [§]	H	M [‡]

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol; BPBP



CASRN: 1003300-73-9

MW: 650.6 (n = 1); 974.8 (n = 2); >1000 (n ≥ 3)

MF: C₃₆H₂₈O₈P₂ (n = 1)

Physical Forms:

Neat: Solid or liquid (depending on oligomer distribution)

Use: Flame retardant

SMILES: O=P(Oc1ccccc1)(Oc1ccccc1)Oc1ccc(cc1)c1ccc(cc1)OP(=O)(Oc1ccccc1)Oc1ccccc1 (n = 1)

c1(c6cc(OP(=O)(Oc8ccc(c4ccc(OP(=O)(Oc9ccccc9)Oc5ccccc5)cc4)cc8)Oc3ccccc3)ccc6)ccc(OP(=O)(Oc7ccccc7)Oc2ccccc2)cc1 (n = 2)

Synonyms: Phosphoric acid, P,P'-[1,1'-biphenyl]-4,4'-diyl P,P,P',P'-tetraphenyl ester; Biphenyl-4,4'-diyl tetraphenyl bis(phosphate); BPBP; ADK STAB FP-800; T-1752F.

Chemical Considerations: The n = 1 (>80% of composition) and n = 2 oligomers are amenable to EPI v4.1 estimation methods for physical/chemical and environmental fate values and ECOSAR v1.11 for ecotoxicity values in the absence of experimental data. The higher MW oligomers (n = 2-4) that have MWs >1,000 are assessed together using information contained in the literature concerning polymer assessment and professional judgment (Boethling et al., 1997).

Polymeric: Yes

Oligomers: The n = 1 structure comprises >80% of the mixture, with the balance primarily made up of higher oligomers (n = 2, 3, 4, etc.).

Analog: Confidential compounds

Endpoint(s) using analog values: Acute and chronic aquatic toxicity, reproductive and developmental effects

Analog Structure: No structure provided for confidential compounds.

Metabolites, Degradates and Transformation Products: None identified. Degradation of Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol has not been well demonstrated in experimental studies (Submitted confidential study); no degradates have been identified. Degradation of Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol by sequential dephosphorylation could produce phenol (CASRN 108-95-2), 4,4'-dihydroxybiphenyl (CASRN 92-88-6) and diphenyl phosphate (CASRN 838-85-7). The importance of dephosphorylation relative to possible competing pathways has not been demonstrated in a published study. Therefore the hazards of the theoretical degradation products were not considered in this hazard assessment.

Structural Alerts: None identified

Risk Phrases: None

Hazard and Risk Assessments: None

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	53 - 83 (Measured) According to Organisation of Economic Cooperation and Development (OECD) 102; using good laboratory practice (GLP)	Submitted confidential studies	Guideline study reported in a submitted confidential study for the polymeric mixture.
	65-85 (Measured)	Adeka-Palmarole, 2013	Guideline study reported for the commercial product ADK STAB FP-800.
Boiling Point (°C)	Not determinable; decomposes above 260°C before boiling according to OECD 103 study; using GLP (Measured)	Submitted confidential studies	Guideline study reported in a submitted confidential study for the polymeric mixture.
	>300 (Estimated for n=1; n=2 oligomers)	EPI; EPA, 1999	Estimate based on the representative oligomers (n=1 and n=2) with a MW <1,000. Cutoff value for high boiling point compounds according to High Production Volume (HPV) assessment guidance.
	>300 (Estimated for n ≥3 oligomers)	Professional judgment	Cutoff value for high boiling point compounds according to HPV assessment guidance.
Vapor Pressure (mm Hg)	4.0x10 ⁻⁷ (Measured) According to OECD 104 study; using GLP.	Submitted confidential studies	Guideline study reported in a submitted confidential study for the polymeric mixture.
	<10 ⁻⁸ (Estimated for n ≥3 oligomers)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW polymers.
	2.1x10 ⁻⁸ (Estimated for n=1; n=2 oligomers)	EPI	Estimate based on the representative oligomers (n=1 and n=2) with a MW <1,000.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Water Solubility (mg/L)	<0.01 (Measured) According to OECD 105 study; using GLP	Submitted confidential studies	Guideline study reported in a submitted confidential study.
	<10 ⁻³ (Estimated) for n=1; n=2	EPI; EPA, 1999	Cutoff value for non soluble compounds according to HPV assessment guidance.
	<10 ⁻³ (Estimated for n ≥ 3 oligomers)	Professional judgment; Boethling et al., 1997	Cutoff value for large high MW polymers.
Log K_{ow}	5.5 (Measured) According to GLP OECD 117 study; high performance liquid chromatography (HPLC) method	Submitted confidential studies	Reported in a submitted confidential study. Sufficient experimental details are not available to evaluate the results, although the reported value is likely for the commercial mixture and not a specific oligomer.
	9.2 (Estimated for n=1); 14 (Estimated for n=2)	EPI; EPA, 1999	Estimated value for n=2 oligomer is greater than the cutoff value, >10, according to methodology based on HPV assessment guidance.
	No data located (for n ≥ 3 oligomers)	Professional judgment	This polymer is not amenable to available estimation methods.
Flammability (Flash Point)	Not highly flammable (Measured) According to a GLP EC method A.14 study	Submitted confidential studies	Reported in a submitted confidential study.
Explosivity	Not explosive (Measured)	Submitted confidential studies	Reported in a submitted confidential study.
Pyrolysis	>400°C (Measured) Auto-ignition temperature; GLP EC method A.15 study	Submitted confidential studies	Reported in a submitted confidential study.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pK _a		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
HUMAN HEALTH EFFECTS				
Toxicokinetics		There were no experimental studies available on the absorption, distribution, metabolism and/or excretion (ADME) of BPBP. Its absorption and systemic availability after topical or oral administration is expected to be limited, because of its MW (650.6), low water solubility (<0.01 mg/L at 20°C) and high lipophilicity (Log K _{ow} = 5.5 at 25°C) and because of the absence of relevant toxicity findings in available toxicity studies. Based on professional judgment, only limited absorption is expected by any route, followed by rapid excretion in feces and urine. This judgment is supported by a closely related analog. Availability of BPBP under a vapor state is unlikely because of its low vapor pressure (4.0 x 10 ⁻⁷ mm Hg at 25°C) and its decomposition at high temperatures prior to boiling. Its availability as an inhalable aerosol is unlikely because of its particle size.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Estimated low potential for absorption expected by any route, followed by rapid excretion in feces and urine (Estimated by analogy)	Submitted confidential studies; Professional judgment	Based on physical-chemical properties and confidential structural analogs.
		No absorption is expected for any route of exposure; poor absorption may be assumed of low MW oligomers (0% <600; 85% <1000) in solution in all routes (Estimated by analogy)		
Acute Mammalian Toxicity		LOW: Based on oral and dermal LD ₅₀ values of >2000 mg/kg in rats for BPBP. No experimental data were available for the inhalation route, but due to mist particle size and solubility properties, the inhalation potential is estimated to be low.		
Acute Lethality	Oral	LD ₅₀ >2000 mg/kg (no deaths)	Submitted confidential study	GLP OECD 420 (fixed dose) study; reported in a submitted confidential study.
	Dermal	LD ₅₀ >2000 mg/kg (no deaths)	Submitted confidential study	GLP OECD 402 study; reported in a submitted confidential study.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Inhalation			No data available; due to particle size and solubility properties assumed low hazard.
Carcinogenicity		MODERATE: BPBP may have low potential for carcinogenicity based on professional judgment; there were no structural alerts in the molecule, and a similar confidential analog was negative for carcinogenicity. However, there is uncertainty regarding the carcinogenicity of BPBP due to the lack of data for this substance. Carcinogenic effects cannot be completely ruled out.		
	OncoLogic Results			No data located; not amenable to available estimation methods.
	Carcinogenicity (Rat and Mouse)	Low potential for carcinogenicity (Estimated based on analogy)	Professional judgment	Professional judgment (based on similar confidential analog); no data located.
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: BPBP was not mutagenic to bacteria <i>in vitro</i> or in mouse lymphocyte (L5178Y) cells. No chromosomal aberrations were detected in an <i>in vitro</i> mammalian chromosomal aberration assay with Chinese hamster fibroblasts.		
	Gene Mutation <i>in vitro</i>	Negative for mutagenicity in <i>S. typhimurium</i> and <i>E. coli</i> (strains not specified; metabolic activation not specified); No relevant cytotoxicity	Submitted confidential study	GLP OECD 471 study; reported in a submitted confidential study.
		Negative for mutagenicity in mouse lymphocyte (L5178Y) cells (metabolic activation unspecified); No relevant cytotoxicity	Submitted confidential study	GLP OECD 476 study; reported in a submitted confidential study.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative for chromosomal aberrations in Chinese hamster fibroblasts (metabolic activation unspecified); No relevant cytotoxicity	Submitted confidential study	GLP OECD 473 study; reported in a submitted confidential study.
	Chromosomal Aberrations <i>in vivo</i>			No data located.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: Estimated based on analogy to a similar confidential analog. There were no reproductive effects reported in studies using a confidential structural analog at doses up to 1,000 mg/kg-day.		
	Reproduction/ Developmental Toxicity Screen	Low potential based on structural analog; No maternal or fetal toxicity reported at 1,000 mg/kg-day NOAEL = 1,000 mg/kg-day (highest dose tested) (Estimated by analogy)	Submitted confidential study; Professional judgment	Estimate based on professional judgment (based on similar confidential analog - GLP OECD 421 study; reported in a submitted confidential study.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects			No data located
Developmental Effects		LOW: Estimated based on analogy to a similar confidential analog. There were no developmental effects reported in a confidential structural analog at doses up to 1,000 mg/kg-day. Although predicted to have low hazard, there is high uncertainty due to lack of data related to developmental neurotoxicity.		
	Reproduction/ Developmental Toxicity Screen	Low potential based on structural analog No maternal or fetal toxicity reported at 1,000 mg/kg-day NOAEL = 1,000 mg/kg-day (highest dose tested) (Estimated by analogy)	Submitted confidential study; Professional judgment	Estimate based on professional judgment (based on similar confidential analog - GLP OECD 421 study; reported in a submitted confidential study.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Prenatal Development			No data located.
	Postnatal Development			No data located.
Neurotoxicity		LOW: There were no neurotoxic effects observed at doses up to 1,000 mg/kg in a 28-day rat oral (gavage) study. Although low hazard is predicted, there is uncertainty due to lack of data on cholinesterase inhibition which is associated with phosphate esters.		
	Neurotoxicity Screening Battery (Adult)	In a 28-day oral (gavage) study, no effects from BPBP on: clinical observations, neurotoxicity parameters, body weight, food intake, hematology, blood chemistry, urine analysis, or pathology. No abnormal observations in the recovery group. NOAEL = 1,000 mg/kg (gavage)	Submitted confidential study	GLP OECD 407 study; reported in a submitted confidential study.
Repeated Dose Effects		LOW: No treatment-related effects were reported in a sub-acute 28-day rat oral (gavage) study with BPBP, indicating a NOAEL of 1,000 mg/kg.		
		In a 28-day study, no effects from BPBP in clinical observations, neurotoxicology parameters, body weight, food intake, hematology, blood chemistry, urine analysis, or pathology. No abnormal observations in the recovery group. NOAEL = 1,000 mg/kg (gavage)	Submitted confidential study	GLP OECD 407 study; reported in a submitted confidential study.
		Low potential based on a 90-day study for a confidential structural analog (Estimated based on analogy)	Professional judgment	Estimate based on professional judgment and data from a confidential structural analog
	Immune System Effects	Low potential for immunotoxicity. (Estimated)	Expert judgment	No data located. Estimated based on expert judgment.
Skin Sensitization		LOW: No sensitizing effect detected in a Mouse Local Lymph Node Assay (LLNA) with BPBP.		
	Skin Sensitization	Not sensitizing; no irritation or relevant increase in ear thickness (LLNA-test)	Submitted confidential study	GLP OECD 429 study; reported in a submitted confidential study.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		VERY LOW: BPBP is not an eye irritant in rabbits.		
	Eye Irritation	Not irritating, rabbits; only minor findings at 1 hour post installation	Submitted confidential study	GLP OECD 405 study; reported in a submitted confidential study.
Dermal Irritation		VERY LOW: BPBP is not a skin irritant in rabbits.		
Dermal Irritation		Not irritating, rabbits; no signs of irritation at any observation time point of the study	Submitted confidential study	GLP OECD 404 study; reported in a submitted confidential study.
Endocrine Activity		No experimental data were located.		
				No data located.
Immunotoxicity		BPBP is estimated to have low potential for immunotoxicity based on expert judgment. No experimental data for this substance were located.		
	Immune System Effects	Low potential for immunotoxicity. (Estimated)	Expert judgment	No data located. Estimated based on expert judgment.
ECOTOXICITY				
ECOSAR Class				
Acute Toxicity		HIGH: Estimated based on an EC₅₀ value of <1.0 mg/L in algae for a structurally similar confidential analog. While ECOSAR estimates for algae indicate no effects at saturation (NES), experimental data is preferred over estimates to determine the hazard designation. The results of experimental studies and estimates for fish and daphnia indicate NES.		
Fish LC₅₀		LC ₅₀ >100 mg/L	Submitted confidential study	GLP OECD 203 study; reported in a submitted confidential study; sufficient experimental details are not available to address why the reported LC ₅₀ is higher than the water solubility.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish 96-hour LC ₅₀ = 0.000193 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES: The log K _{ow} of 9.2 for this n=1 oligomer exceeds the SAR limitation of log K _{ow} 5.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Fish 96-hour LC ₅₀ = 0.0000000279 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES: The log K _{ow} of 14 for this n=2 oligomer exceeds the SAR limitation of log K _{ow} 5.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Daphnid LC₅₀	EC ₅₀ >100 mg/L	Submitted confidential study	GLP OECD 202 study; reported in a submitted confidential study; sufficient experimental details are not available to address why the reported LC ₅₀ is higher than the water solubility.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnid 48-hour LC ₅₀ = 0.000213 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES: The log K _{ow} of 9.2 for this n=1 oligomer exceeds the SAR limitation of log K _{ow} 5.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Daphnid 48-hour LC ₅₀ = 0.0000000465 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES: The log K _{ow} of 14 for this n=2 oligomer exceeds the SAR limitation of log K _{ow} 5.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Green Algae EC₅₀	Green algae NOEC >100 mg/L	Submitted study	GLP OECD 201 study submitted to EPA; study methodology has limitations due to the limited water solubility of this substance. Sufficient experimental details are not available to address why the reported NOEC is higher than the water solubility.
	Green algae EC ₅₀ <1.0 mg/L	Submitted confidential study	Reported in a submitted confidential study.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae 96-hour EC ₅₀ = 0.002 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES: The log K _{ow} of 9.2 for this n=1 oligomer exceeds the SAR limitation of log K _{ow} 6.4. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Green algae 96-hour EC ₅₀ = 0.00000295 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES: The log K _{ow} of 14 for this n=2 oligomer exceeds the SAR limitation of log K _{ow} 6.4 ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Toxicity to microorganisms	NOEC $\geq$ 1,000 mg/L	Submitted confidential study	GLP OECD 209 study; reported in a submitted confidential study.
Chronic Aquatic Toxicity	HIGH: Estimated based on a NOEC value of <0.1 mg/L in algae for a structurally similar confidential analog. While ECOSAR estimates for algae indicate NES, experimental data are preferred over estimates to determine the hazard designation. The results of estimates for fish and daphnia indicate NES.		
	Fish ChV = 0.0000413 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000. NES: The log K _{ow} of 9.2 for this n=1 oligomer exceeds the SAR limitation of log K _{ow} 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Fish ChV = 0.00000000971 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000. NES: The log K _{ow} of 14 for this n=2 oligomer exceeds the SAR limitation of log K _{ow} 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid ChV	Daphnid Daphnid ChV = 0.000131 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000. NES: The log K _{ow} of 9.2 for this n=1 oligomer exceeds the SAR limitation of log K _{ow} 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Daphnid Daphnid ChV = 0.0000000903 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000. NES: The log K _{ow} of 14 for this n=2 oligomer exceeds the SAR limitation of log K _{ow} 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Green Algae ChV	Green algae NOEC <0.1 mg/L (Estimated by analogy)	Submitted confidential study	Reported in a submitted confidential study.
	Green algae ChV = 0.003 mg/L (Estimated for n=1) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000. NES: The log K _{ow} of 9.2 for this n=1 oligomer exceeds the SAR limitation of log K _{ow} 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Green algae ChV = 0.00000847 mg/L (Estimated for n=2) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000. NES: The log K _{ow} of 14 for this n=2 oligomer exceeds the SAR limitation of log K _{ow} 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The environmental fate is described using estimates on the lowest MW oligomer of BPBP, which is the predominant component. Based on the Level III fugacity models incorporating the available experimental property data, the lowest MW oligomer is expected to partition primarily to soil and sediment. BPBP is expected to be immobile in soil based on the measured K_{oc} of the commercial mixture. Leaching of BPBP through soil to groundwater is not expected to be an important transport mechanism. Estimated volatilization half-lives indicate that BPBP will be non-volatile from surface water. Volatilization from dry surfaces is also not expected based on its vapor pressure. In the atmosphere, BPBP is expected to exist solely in the particulate phase, based on its measured vapor pressure. Particulates may be removed from air by wet or dry deposition. The higher MW components of the commercial product are anticipated to behave similarly to that described above.		
	Henry's Law Constant (atm-m³/mole)	<10 ⁻⁸ (Estimated for the n=1; n=2 oligomers)	EPI; Professional judgment	Estimated based on predominant oligomer components. The higher MW oligomers are also expected to have Henry's Law Constant values below this cutoff.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	4.6 x 10 ⁵ (Measured) Calculated from the reported Log ₁₀ K_{oc} = 5.7; according to HPLC method OECD 121 study; using GLP	Submitted confidential study	Confidential guideline study.
	Level III Fugacity Model	Air: <1% (Estimated) Water: 1% Soil: 42% Sediment: 57%	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 80% of the commercial mixture.
		Air: <1% (Estimated) Water: 3.7% Soil: 94% Sediment: 2%	EPI	Estimate based on the n=2 oligomer component.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Persistence		HIGH: BPBP was not readily biodegradable in a guideline Japanese Ministry of International Trade and Industry (MITI)-I test (1% biodegradation in OECD TG 301C). The n≥3 oligomers, with a MW >1,000 are expected to have negligible water solubility and poor bioavailability to microorganisms indicating that biodegradation is not expected to be an important removal process in the environment. Abiotic degradation by hydrolysis is limited due to the low water solubility of BPBP (<0.01 mg/L). Similar to other phosphate esters, BPBP hydrolysis is expected to be dependent on pH, occurring slowest under neutral and acidic conditions. BPBP oligomers (n=1 and n=2) do not contain chromophores that absorb at wavelengths >290 nm, and therefore, are not expected to be susceptible to direct photolysis by sunlight. Enzymatic or basic hydrolysis leading to the production of phenol (CASRN 108-95-2), 4,4'-dihydroxybiphenyl (CASRN 92-88-6) and diphenyl phosphate (CASRN 838-85-7) through sequential dephosphorylation is theoretically possible but has not been demonstrated.		
Water	Aerobic Biodegradation	Not readily biodegradable 1% biodegradation detected after 28 days in activated sludge; GLP OECD 301C MITI-I study (Measured)	Submitted confidential study	Confidential guideline study.
		Days (Primary survey model) Months (Ultimate survey model) (Estimated)	EPI	Estimated data based on the predominant oligomer component, n = 1, representing 80% of the commercial mixture.
		Days (Primary survey model) Recalcitrant (Ultimate survey model) (Estimated)	EPI	Estimated data based on the n=2 oligomer.
		Recalcitrant (Estimated for n ≥3 oligomers)	Professional judgment; Boethling et al, 1997	High MW polymers are expected to be non-biodegradable.
	Volatilization Half-life for Model River	>1 year (Estimated for the n=1; n=2 oligomers)	EPI	Estimate based on the n= 1 and n=2 oligomer components.
	Volatilization Half-life for Model Lake	>1 year (Estimated for the n=1; n=2 oligomers)	EPI	Estimate based on the n= 1 and n=2 oligomer components.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Soil	Aerobic Biodegradation			No data available.
	Anaerobic Biodegradation	Not probable (Anaerobic-methanogenic biodegradation probability model) (Estimated)	EPI	Estimated data based on the n=1 and n=2 oligomers.
	Soil Biodegradation w/ Product Identification			No data available.
	Sediment/Water Biodegradation			No data available.
Air	Atmospheric Half-life	6.5 hours (Estimated)	EPI	Estimate based on the n= 1 oligomer component.
		3.9 hours (Estimated)	EPI	Estimate based on the n=2 oligomer component.
Reactivity	Photolysis	Not a significant fate process	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	>1 year at pH 7; 44 days at pH 8 4.4 days at pH 9 (Estimated for n=1)	EPI	Hydrolysis rates are expected to be pH-dependent and may be limited the by low water solubility of this compound. Under basic conditions, sequential dephosphorylation reactions may occur.
		>1 year at pH 7; 40 days at pH 8 4 days at pH 9 (Estimated for n=2)	EPI	
Environmental Half-Life		>1 year (Estimated for n=1)	EPI; PBT Profiler	Half-life estimated for the predominant compartment (sediment), as determined by EPI and the PBT Profiler methodology.
		>1 year (Estimated for n=2)	EPI; PBT Profiler	Half-life estimated for the predominant compartment (soil), as determined by EPI and the PBT Profiler methodology.

Phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol CASRN 1003300-73-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Bioaccumulation		MODERATE: Although measured BCF values for a commercial mixture result in a Low bioaccumulation hazard designation, the overall bioaccumulation designation is Moderate based on the estimated BCF value for the predominant oligomer component, n = 1, representing 80% of the commercial mixture. The higher MW oligomers that may be found in this mixture (n=2, 3, 4) are expected to have low potential for bioaccumulation.		
	Fish BCF	172 (Estimated for n=1) 3.2 (Estimated for n=2)	EPI	
		<100 (Estimated for n≥3 oligomers)	Professional judgment	The components with a MW >1,000 are not anticipated to be taken up by aquatic organisms; therefore, bioconcentration is not expected.
		12 (Measured) According to GLP OECD 305C; on the commercial product	Confidential study	Guideline study on the commercial product mixture. This study did not assess the concentration of each oligomer in either the water or the fish. Therefore the BCF of the individual components of the mixture could not be determined.
	BAF	34 (Estimated for n=1) 27 (Estimated for n=2)	EPI	
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2013).		

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PBT Profiler. *Persistent (P), Bioaccumulative (B), and Toxic (T) Chemical (PBT) Profiler*. U.S. Environmental Protection Agency: Washington D.C. www.pbtprofiler.net.

Polyphosphonate

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

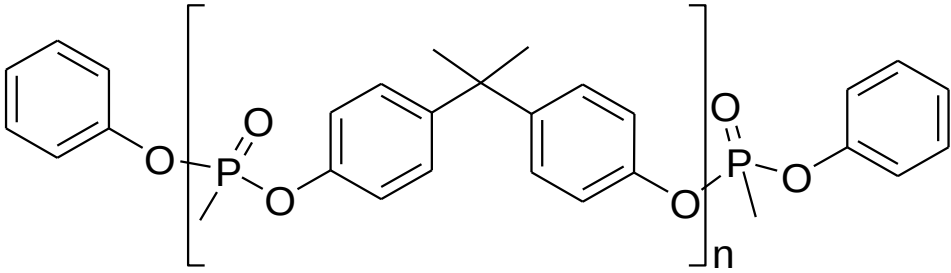
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Polyphosphonate	68664-06-2	L	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i> ^d	<i>L</i>		<i>L</i>	<i>L</i>	<i>L</i>	<i>L</i>	VH	<i>L</i>

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Polyphosphonate

 Representative structure	
CASRN: 68664-06-2	
MW: 10,000 to 50,000; <1% MW <1,000	
MF: C ₁₅ H ₁₆ O ₂ (C ₁₆ H ₁₇ O ₃ P) _n	
Physical Forms: Solid	
Use: Flame retardant	
SMILES: The polymer components with MW >1,000 are not amenable to SMILES notation.	
Synonyms: Nofia® HM1100; FRX 100 (polyphosphonate) (Polymeric additive); FRX100; Phosphonic acid, P-methyl-, diphenyl ester, polymer with 4,4'-(1-methylethylidene)bis[phenol]	
Chemical Considerations: This alternative is a high MW polymer with <1% low (<1,000) MW oligomers. The high MW oligomers, with a MW >1,000, are assessed together using the professional judgment and information contained in the literature concerning polymer assessment (Boethling et al., 1997).	
Polymeric: Yes Oligomers: The polymer is produced from the condensation of methyldiphenylphosphonate and bisphenol A equivalents. The MW of polyphosphonate ranges between 10,000 and 50,000. Oligomers with MW <1,000 are expected to be present at <1% in the polyphosphonate mixture. Phenoxy terminated oligomers are anticipated to predominate.	
Metabolites, Degradates and Transformation Products: None	
Analog: No analog Endpoint(s) using analog values: Not applicable	Analog Structure: Not applicable
Structural Alerts: No data located.	
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).	
Hazard and Risk Assessments: None identified.	

Polyphosphonate CASRN 68664-06-2			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	90 softening point (Measured)	FRX Polymers, Inc., 2009	The value corresponds to a softening point for the polymer.
Boiling Point (°C)	>300 (Estimated)	Professional judgment	Cutoff value used for large, high MW solids.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW polymers.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
Log K _{ow}			No data located; polymers with a MW >1,000 are outside the domain of the available estimation methods.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Polyphosphonate CASRN 68664-06-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		No absorption is expected for any route of exposure for polyphosphonate. This polymer is large, with a MW >1,000. Based on professional judgment, it is expected to have limited bioavailability and therefore is not expected to be readily absorbed, distributed or metabolized in the body.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption is expected for any route of exposure (Estimated)	Professional judgment	Estimated based on professional judgment.
Acute Mammalian Toxicity		LOW: Based on experimental LD ₅₀ values >2,000 mg/kg. This compound is also expected to have limited bioavailability and therefore has low potential for acute mammalian toxicity.		
	Oral	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoffs for large high MW polymers
		Rat oral LD ₅₀ >2,000 mg/kg	FRX Polymers, Inc., 2011	Conducted according to Organisation of Economic Cooperation and Development420; test substance: FRX polyphosphonate.
	Dermal			No data located.
	Inhalation			No data located.
Carcinogenicity		LOW: This polymer is large, with a MW >1,000. Based on professional judgment, it is expected to have few to no residual monomers. Additionally, crosslinking, swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected. Therefore, there is low potential for carcinogenicity.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	Limited bioavailability expected; crosslinking, swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected.	Professional judgment; Boethling et al., 1997	Based on cutoffs for large high MW polymers.
	Combined Chronic Toxicity/ Carcinogenicity	(Estimated)		

Polyphosphonate CASRN 68664-06-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Genotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for genotoxicity.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Gene Mutation <i>in vivo</i>			
	Chromosomal Aberrations <i>in vitro</i>			
	Chromosomal Aberrations <i>in vivo</i>			
	DNA Damage and Repair			
	Other (Mitotic Gene Conversion)			
Reproductive Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for reproductive effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for developmental effects.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al.,1997	Based on cutoff values for large high MW polymers.

Polyphosphonate CASRN 68664-06-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for neurotoxicity.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW _n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
		This polymer's MW _n is >10,000; potential for irreversible lung damage as a result of lung overloading. (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Skin Sensitization		LOW: Based on expert judgment, polyphosphonate is estimated not to have potential for skin sensitization		
	Skin Sensitization	Not expected to be a skin sensitizer (Estimated)	Expert judgment	Estimated based on expert judgment by analogy to other high MW polymers with similar structural features.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Based on expert judgment, polyphosphonate is estimated not to have potential for eye irritation.		
	Eye Irritation	Not expected to be an eye irritant (Estimated)	Expert judgment	Estimated based on expert judgment by analogy to other high MW polymers with similar structural features.

Polyphosphonate CASRN 68664-06-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Dermal Irritation		LOW: Based on expert judgment, polyphosphonate is estimated not to have potential for dermal irritation.		
	Dermal Irritation	Not expected to be a skin irritant (Estimated)	Expert judgment	Estimated based on expert judgment by analogy to other high MW polymers with similar structural features.
Endocrine Activity		No data located. This polymer is large, with a MW >1,000. Based on professional judgment, polyphosphonate is not expected to have endocrine activity due to its poor bioavailability and inability to be readily metabolized in the body.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Immunotoxicity		Based on professional judgment polyphosphonate is expected to have limited bioavailability and therefore has low potential for hazard.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to have no effects at saturation (NES). These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Bioavailability is limited because this chemical cannot be absorbed through membranes due to its large size.		
Fish LC₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

Polyphosphonate CASRN 68664-06-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Chronic Aquatic Toxicity		LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to display NES. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Bioavailability is limited because this chemical cannot be absorbed through membranes due to its large size.		
Fish ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that this polymer is anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of $<10^{-8}$ atm-m³/mole indicates that it is not expected to volatilize from water to the atmosphere. The estimated K_{oc} of >30,000 indicates that it is not anticipated to migrate from soil into groundwater and also has the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m³/mole)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value used for large, high MW polymers. High MW polymers are expected to adsorb strongly to soil and sediment.

Polyphosphonate CASRN 68664-06-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: This polymer is large, with a MW >1,000. It is expected to have negligible water solubility and poor bioavailability to microorganisms indicating that neither biodegradation nor hydrolysis are expected to be important removal processes in the environment. The polymer does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths. Evaluation of these degradation values suggest a half-life of >180 days.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; EPA, 2010	High MW polymers are expected to be non-biodegradable.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	This high MW polymer is anticipated to be nonvolatile.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	This high MW polymer is anticipated to be nonvolatile.
Soil	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.
	Anaerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be resistant to removal under anoxic conditions due to their limited bioavailability.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.

Polyphosphonate CASRN 68664-06-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.
Environmental Half-life		>180 days (Estimated)	Professional Judgment	The majority of this substance has a MW >1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to be removed by other degradative processes under environmental conditions because of limited water solubility and limited partitioning to air.
Bioaccumulation		LOW: This polymer is large, with a MW >1,000. It is expected to have poor bioavailability indicating that this polymer should be of low potential for bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment	The majority of this substance has a MW >1,000 and is not anticipated to be taken up by aquatic organisms; therefore, bioconcentration is not expected.
	BAF			No data located.
	Metabolism in Fish			No data located.

Polyphosphonate CASRN 68664-06-2			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL MONITORING AND BIOMONITORING			
Environmental Monitoring	No data located.		
Ecological Biomonitoring	No data located.		
Human Biomonitoring	This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

Boethling, Robert S. and Nabholz, J. Vincent “Environmental Assessment of Polymers under the U.S. Toxic Substances Control Act”, pp. 187-234, in Ecological Assessment of Polymers Strategies for Product Stewardship and Regulatory Programs, Hamilton, John D. and Sutcliffe, Roger (eds.), (1997) Van Nostrand Reinhold.

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European Chemical Substances Information System (ESIS) Classification, Labeling and Packaging of Dangerous Substances Annex VI to Regulation (EC) No 1272/2008 [Online] available at: <http://esis.jrc.ec.europa.eu/home.php> as of May 10, 2011.

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Mill, T. (2000) Photoreactions in Surface Waters. In Boethling, R.; Mackay, D., *Handbook of Property Estimation Methods for Chemicals*, Environmental Health Sciences (355-382). Boca Raton: Lewis Publishers.

Poly[phosphonate-co-carbonate]

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame-retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

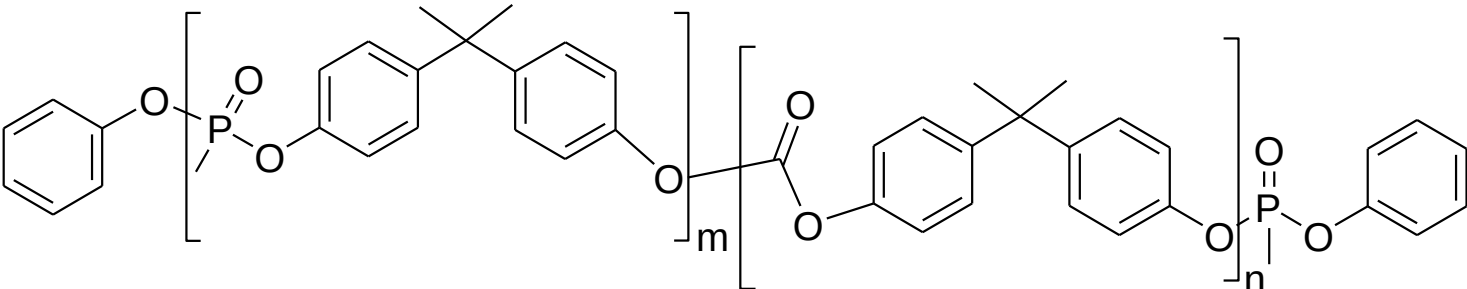
VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

^d This hazard designation would be assigned MODERATE if >5% of the particles are in the respirable range as a result of dust forming operations.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Poly[phosphonate-co-carbonate]	77226-90-5	L	L	L	L	L	L	L^d	L		L	L	L	L	VH	L

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Poly[phosphonate-co-carbonate]

		CASRN: 77226-90-5
		MW: >1,000; <1% <1,000
		MF: C ₁₅ H ₁₆ O ₂ (C ₁₆ H ₁₄ O ₃) _n (C ₁₆ H ₁₇ O ₃ P) _m
		Physical Forms: Neat: Solid
		Use: Flame retardant
Representative structure		
SMILES: This polymer with MW >1,000 and <1% low MW components is not amenable to SMILES notation.		
Synonyms: Nofia® CO3000; Nofia® CO6000; Carbonic acid, diphenyl ester, polymer with diphenyl P-methylphosphonate and 4,4'- (1-methylethylidene)bis[phenol]; FRX CO35; FRX CO60		
Chemical Considerations: This alternative is a polymer. Poly[phosphonate-co-carbonate] polymers differ in their ratio of polyphosphonate/polycarbonate (m to n) but would have identical hazard characterizations. The MW of the oligomers are generally >1,000 and are assessed using information contained in the literature concerning polymer assessment and professional judgment (Boethling et al., 1997). Representative structure drawn to show simplest combination of all feedstock.		
Polymeric: Yes Oligomers: The MW for the Poly[phosphonate-co-carbonate] polymers range between 10,000 and 50,000; with <1% MW <1,000 oligomers expected. Phenoxy terminated oligomers are anticipated to predominate.		
Metabolites, Degradates and Transformation Products: None		
Analog: No analog Endpoint(s) using analog values: Not applicable		Analog Structure: Not applicable
Structural Alerts: None identified.		
Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).		
Hazard and Risk Assessments: None identified.		

Poly[phosphonate-co-carbonate] CASRN 77226-90-5			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	220–250 (glass transition temperature) (Measured)	FRX Polymers, Inc., 2009	The melting points reported cover a broad range and are anticipated to be the formulation specific liquid-glass transition temperature or softening point.
	120 (softening point) (Measured)	FRX Polymers, Inc., 2009	
Boiling Point (°C)	>300 (Estimated)	Professional judgment	Cutoff value used for large, high MW solid.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	Cutoff value for large, high MW polymers.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	Professional judgment, Boethling et al., 1997	Cutoff value for large, high MW non-ionic polymers.
	Insoluble (Measured)	FRX Polymers, Inc., 2009	Nonspecific value provided by commercial supplier.
Log K _{ow}			No data located.
Flammability (Flash Point)	>450°C (Measured)	FRX Polymers, Inc., 2009	Sufficient details were not available to assess the quality of this study.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Poly[phosphonate-co-carbonate] CASRN 77226-90-5

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		There is no absorption expected for any route of exposure for the neat material. Poor absorption of the low MW fraction in solution can be expected for all routes. This polymer is large, with a MW >1,000. Based on professional judgment, it is expected to have limited bioavailability and therefore is not expected to be readily absorbed, distributed or metabolized in the body.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption of the neat material is expected for any route of exposure; poor absorption of low MW fraction in solution for all routes. (Estimated)	Professional judgment	Estimated based on physical/chemical properties and limited bioavailability.
Acute Mammalian Toxicity		LOW: Based on experimental LD₅₀ values >2,000 mg/kg. This compound is also expected to have limited bioavailability and therefore is of low potential for acute mammalian toxicity.		
Acute Lethality	Oral	Rat oral LD ₅₀ >2,000 mg/kg	FRX Polymers, Inc., 2011	Conducted according to Organisation of Economic Cooperation and Development420; test substance: FRX polyphosphonate.
	Dermal	Limited bioavailability expected	Professional judgment;	Based on cutoff values for large
	Inhalation	(Estimated)	Boethling et al., 1997	high MW polymers.
Carcinogenicity		LOW: This polymer is large, with a MW >1,000. Based on expert judgment, it is expected to have few to no residual monomers. Additionally, crosslinking, swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected. Therefore, there is low potential for carcinogenicity based on professional judgment and the polymer assessment literature. No data located.		
	OncoLogic Results	Limited bioavailability expected;	Professional judgment;	Based on cutoff values for large
	Carcinogenicity (Rat and Mouse)	crosslinking, swellability, dispersability, reactive functional groups, inhalation potential, and hindered amine groups are not expected.	Boethling et al., 1997	high MW polymers.
	Combined Chronic Toxicity/ Carcinogenicity	(Estimated)		

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Poly[phosphonate-co-carbonate] CASRN 77226-90-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Genotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for genotoxicity based on professional judgment.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Gene Mutation <i>in vivo</i>			
	Chromosomal Aberrations <i>in vitro</i>			
	Chromosomal Aberrations <i>in vivo</i>			
	DNA Damage and Repair			
	Other (Mitotic Gene Conversion)			
Reproductive Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for reproductive effects based on professional judgment.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			

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Poly[phosphonate-co-carbonate] CASRN 77226-90-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Developmental Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for developmental effects based on professional judgment.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability and therefore has low potential for neurotoxicity based on professional judgment.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Repeated Dose Effects		LOW: This polymer is large, with a MW >1,000. It is expected to have limited bioavailability; however, because the MW _n is >10,000, there is the possibility of lung overloading if >5% of the particles are in the respirable range as a result of dust forming operations.		
		Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
		This polymer's MW _n is >10,000; potential for irreversible lung damage as a result of lung overloading (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Skin Sensitization		LOW: Estimated not to have potential for skin sensitization based on expert judgment. No data located.		
	Skin Sensitization	Not expected to be a skin sensitizer (Estimated)	Expert judgment	Estimated based on expert judgment.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Eye Irritation		LOW: Uncertain potential for irritation based on the phenol moieties and professional judgment. No data located.		
	Eye Irritation	Uncertain potential for irritation based on the phenol moieties. (Estimated)	Professional judgment	Estimated based on cutoff values for large high MW polymers.
Dermal Irritation		LOW: Uncertain potential for irritation based on the phenol moieties and professional judgment. No data located.		
	Dermal Irritation	Uncertain potential for irritation based on the phenol moieties. (Estimated)	Professional judgment	Estimated based on cutoff values for large high MW polymers.
Endocrine Activity		No data located. This polymer is large, with a MW >1,000. Based on expert judgment, it is not expected to have endocrine activity due to its poor bioavailability and inability to be readily metabolized in the body.		
		Limited bioavailability expected (Estimated)	Professional judgment Boethling et al., 1997	Based on cutoff values for large high MW polymers.
Immunotoxicity		This polymer is large, with a MW >1,000. Based on expert judgment, it is expected to have limited bioavailability and therefore has low potential for hazard.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; Boethling et al., 1997	Based on cutoff values for large high MW polymers.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to display no effects at saturation (NES). These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Bioavailability is limited because this chemical cannot be absorbed through membranes due to large size.		
Fish LC₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Daphnid LC₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.

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Poly[phosphonate-co-carbonate] CASRN 77226-90-5				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Green Algae EC ₅₀		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity		LOW: Non-ionic polymers with a MW >1,000 that do not contain reactive functional groups and are comprised of minimal low MW oligomers are estimated to display NES. These polymers display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed. Guidance for the assessment of aquatic toxicity hazard leads to a low potential for hazard for those materials that display NES.		
Fish ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will NES.
Daphnid ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
Green Algae ChV		NES	Professional judgment	The large MW, limited bioavailability and low water solubility suggest there will be NES.
ENVIRONMENTAL FATE				
Transport		The estimated negligible water solubility and estimated negligible vapor pressure indicate that these polymers are anticipated to partition predominantly to soil and sediment. The estimated Henry's Law Constant of <10 ⁻⁸ atm-m ³ /mole indicates that these are not expected to volatilize from water to the atmosphere. The estimated K _{oc} of >30,000 indicates that they are not anticipated to migrate from soil into groundwater and have the potential to adsorb to sediment.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to have low vapor pressure and are not expected to undergo volatilization.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to adsorb strongly to soil and sediment.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Level III Fugacity Model			No data located.
Persistence		VERY HIGH: A very limited fraction of these polymers is expected to have a MW of <1,000; therefore, they are not anticipated to be assimilated by microorganisms and biodegradation is not expected to be an important removal process. They are also not expected to be removed by other degradative processes under environmental conditions because of limited water solubility and limited partitioning to air. They are expected to partition primarily to sediment and soil, where their estimated half-life is >1 year. The polymers lack the functional groups that hydrolyze under environmental conditions. These polymers do not contain chromophores that absorb at wavelengths >290 nm, and therefore, they are not expected to be susceptible to direct photolysis by sunlight.		
Water	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	Most high MW polymers are expected to be non-biodegradable.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	This high MW polymer is anticipated to be nonvolatile.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	This high MW polymer is anticipated to be nonvolatile.
Soil	Aerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment; Boethling et al., 1997	High MW polymers are expected to be non-biodegradable.
	Anaerobic Biodegradation	Recalcitrant (Estimated)	Professional judgment	High MW polymers are expected to be resistant to removal under anoxic conditions due to their limited bioavailability.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Hydrolysis	>1 year (Estimated)	Professional judgment	Given the limited solubility estimated for this material, hydrolysis is not anticipated to occur to an appreciable extent.
Environmental Half-Life		>180 days (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to be removed by other degradative processes under environmental conditions because of limited water solubility and limited partitioning to air.
Bioaccumulation		LOW: These polymers are expected to have negligible water solubility and poor bioavailability indicating that these polymers should have low potential for bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment	The substance has a MW >1,000 and is not anticipated to be assimilated by aquatic organisms; therefore, bioconcentration is not expected.
	BAF			No data located.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Red Phosphorus

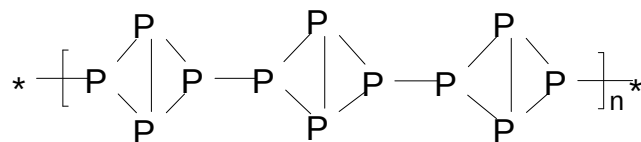
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance, including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Red Phosphorus	7723-14-0	L	L	M	L	L	L	L	L		M	M	L	L	H	L

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Red Phosphorus



CASRN: 7723-14-0

MW: >1,000 (Estimated)

MF: (P₄)_n

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: This polymeric form of elemental phosphorous is not amenable to SMILES notation.

Synonyms: Phosphorus; Red amorphous phosphorus; Violet phosphorus; Exolit RP 605; Exolit RP 650; Exolit RP 652; Exolit RP 654; Hishigado; Hishigado AP; Hishigado CP; Hishigado NP 10; Hishigado PL; Hostaflam RP 602; Hostaflam RP 614; Hostaflam RP 622; Hostaflam RP 654; Novared 120UF; Novared 120UFA; Novared 120VFA; Novared 140; Novared 280; Novared C 120; Novared F 5; Novaexcel 140; Novaexcel 150; Novaexcel F 5; Novaexcel ST 100; Novaexcel ST 140; Novaexcel ST 300

Chemical Considerations: This alternative is an inorganic compound. Red phosphorus refers specifically to the crystalline and amorphous forms of elemental phosphorus which are red in color and consist of random networks of P₄-tetrahedron links. This assessment on red phosphorous does not address other allotropes of elemental phosphorus. White, yellow or black phosphorus do not necessarily have the same properties, fate, or toxicity as red phosphorus. Not all literature entries identify which allotropic form is discussed (Daubert and Danner, 1989; Kelly, 2006).

Polymeric: The elemental form of red phosphorous produced commercially is an amorphous solid (Brummer et al., 2005).

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: Phosphine (CASRN 7803-51-2), phosphorus oxides, hypophosphorus acid (CASRN 6303-21-5), phosphoric acid (CASRN 7664-38-2)

Analog: No analog

Endpoint(s) using analog values: Not applicable

Analog Structure: Not applicable

Structural Alerts: None

Risk Phrases: 11- Highly flammable; 16- Explosive when mixed with oxidizing substances; 52/53- Harmful to aquatic organisms; may cause long-term adverse effects in the aquatic environment (ESIS, 2011). The risk phrases 52/53 are likely to be appropriate only for the yellow/white allotrope of phosphorus which shares a CASRN and an EINECS number with red phosphorus and is generally considered more toxic and reactive than red phosphorus.

Hazard and Risk Assessments: Risk assessments completed in 2007 for red phosphorus by the Danish Environmental Protection Agency (Stuer-Lauridsen et al., 2007) and the Maine Department of Environmental Protection (Maine DEP, 2007).

Red Phosphorus CASRN 7723-14-0

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	Sublimation point: 416°C (Measured) Triple point: 589.5°C at 43.1 atm	O'Neil, 2010	This substance sublimates.
	Sublimation point: 431°C (Measured) Triple point: 590°C	Lide, 2008	
	>590°C (Measured)	IUCLID, 2000	Inadequate; nonspecific value.
Boiling Point (°C)	Sublimation point: 416°C (Measured) Triple point: 589.5°C at 43.1 atm	O'Neil, 2010	This substance sublimates.
	Sublimation point: 431°C (Measured) Triple point: 590°C	Lide, 2008	
	>400°C (Measured)	IUCLID, 2000	Inadequate; appears to be a cutoff value, and is inconsistent with the reported ability for red phosphorous to sublime.
Vapor Pressure (mm Hg)	0.03 at 21°C (Measured)	Sigma-Aldrich, 2011	Adequate, consistent values, which span a relatively narrow range.
	0.05 at 25°C (Measured)	EPA, 2010	
	1 at 237°C (Measured)	Spangord et al., 1983	This value was measured at an elevated temperature.
	<0.075 at 20°C (Measured)	IUCLID, 2000	Inadequate; nonspecific value.
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	Professional judgment; EPA, 1999	Based on this chemical's high MW amorphous structure; cutoff value for substances that are not anticipated to display appreciable water solubility according to the High Production Volume (HPV) assessment guidance.
	Not soluble or insoluble (Measured)	IUCLID, 2000; Stuer-Lauridsen et al., 2007; Lide, 2008	Qualitative descriptions consistent with the low water solubility anticipated for red phosphorous.
	Red phosphorus does not dissolve in water without decomposition (Measured)	Beard, 2000	

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Log K_{ow}			No data located; elemental inorganic materials are outside the estimation domain of EPI estimation models.
Flammability (Flash Point)	Red phosphorus ignites in air at approximately 300°C (Measured)	Diskowski and Hofmann, 2000	Adequate.
	Highly flammable (Measured)	Stuer-Lauridsen et al., 2007	Supporting qualitative value.
	Ignited by friction, static electricity, heating or by oxidizing agents (Measured)	EPA, 2010; Clariant, 2010	Reported in a secondary source, no study details provided.
Explosivity	May explode when exposed to heat or by chemical reaction with oxidizers. It does not react until >260°C. (Measured)	Stuer-Lauridsen et al., 2007	Adequate.
Pyrolysis	Releases phosphorus oxides and phosphorus acids depending on the available oxygen content while burning. (Measured)	Leisewitz et al., 2001	Adequate.
pH	5-6 at 100 g/L and 20°C (Measured)	IUCLID, 2000	Red phosphorous slowly hydrolyzes to phosphoric acid in the presence of oxygen; therefore the pH of a water solution would be dependent on both its age and concentration.
pK_a		Professional judgment	The substance does not contain functional groups that would be expected to ionize.

Red Phosphorus CASRN 7723-14-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
HUMAN HEALTH EFFECTS				
Toxicokinetics		Red phosphorus is not absorbed through the skin and is expected to have poor absorption from the lung and the gastrointestinal tract.		
Dermal Absorption <i>in vitro</i>		Red phosphorus is practically unabsorbable	HSDB, 2011	Reported in a secondary source; limited study details provided.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Not absorbed from the skin, poor absorption from the lung and gastrointestinal tract (Estimated by analogy)	Professional judgment	Based on analogy to similar compounds.
		Not absorbed through the gastrointestinal tract and, therefore, relatively harmless when ingested	HSDB, 2011	Reported in a secondary source; limited study details provided.
Acute Mammalian Toxicity		LOW: Based on oral LD ₅₀ values >10,000 mg/kg in rats. Several studies reported values that fall within the criteria range for a Very High hazard designation; however, the allotrope of phosphorous used could not be verified and the experimental details from the studies could not be assessed. Some studies of red phosphorus in mixtures with butyl rubber showed toxicity: red phosphorus and butyl rubber (RP-BR) smoke at concentrations between 0.1-5.3 mg/L caused mild histological changes in the respiratory tract, respiratory distress, laryngeal lesions and pulmonary congestion in several animal studies (including human) following exposure. This profile is not assessing mixtures.		
Acute Lethality	Oral	Rat, mouse LD ₅₀ : 11.5 mg/kg	RTECS; Maine DEP, 2007	Reported in secondary sources; the form of phosphorus is not specified therefore this value is unverifiable.
		Rabbit LD ₅₀ : 105 mg/kg	RTECS	Reported in a secondary source; this value is unverifiable.
		Cat, dog LD ₅₀ : 5 mg/kg	RTECS	Reported in a secondary source; this value is unverifiable.
		Rat LD ₅₀ >10,000 mg/kg-bw - 15,000 mg/kg-bw	ECHA, 2012; NRC, 1997; Maine DEP, 2007	Unpublished studies reported in secondary sources; studies conducted according to Organisation of Economic Cooperation and Development guidelines.

Red Phosphorus CASRN 7723-14-0

Red Phosphorus CASRN 7723-14-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Single dosage of 0.66 mg/kg did not produce mortality in rabbits or guinea pigs. Cirrhosis-like symptoms were observed.	Maine DEP, 2007	Reported in secondary sources.
	Inhalation	Rat, rabbit LC _{Lo} = 0.15 mg/L (150 mg/m ³) Cardiac: EKG changes not diagnostic of specified effects; Liver: fatty liver, degeneration; Kidney/ureter/bladder: other changes.	RTECS	Reported in a secondary source.
		Rat LC ₅₀ (1 -hour exposures): 2.32-4.3 mg/L (2,320 – 4,300 mg/m ³)	NRC, 1997; Maine DEP, 2007	Reported in secondary sources.
		Sprague Dawley rats and Beagle dogs exposed to RP-BR and black powder mixture at 1.128-1.882 mg/L (1,128-1,882 mg/m ³). Exposure: 60-240 minutes (rats) or 30-240 minutes (dogs) Respiratory distress (leading to prostration and death in some cases). Transient hypoactivity, salivation, conjunctivitis.	EPA, 2010	Adequate; however, study details are not available; reported in a secondary source.

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Red Phosphorus CASRN 7723-14-0			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Sprague Dawley rats exposed to an aerosol generated by combustion of RP/BR for 1 or 4 hours. 1 hour exposures: 3.15, 4.33, 5.36 or 8.46 mg/L (3,150, 4,330, 5,360, 8,460 mg/m³) 4 hour exposure: 1.53 mg/L (1,530 mg/m³) 1-hour LC₅₀ = 4.597 mg/L (4,597 mg/m³) Slightly-moderately deformed epiglottis (blunted tip or partially to virtually absent, ulceration, edema); laryngeal lesions (severe ulceration and edema with fibrin substance on the mucosal surface of the ventral larynx); moderate-severe pulmonary congestion, edema, hemorrhage.	EPA, 2010	Reported in a secondary source.
	Porton Wistar rats exposed to combustion aerosols of red phosphorus at 3.1 or 3.2 mg/L (3,100 or 3,200 mg/m³) for 30 minutes. Laryngeal inflammation, blood in tracheal lumen, severe pulmonary congestion and edema, hepatic congestion.	EPA, 2010	Reported in a secondary source.

Red Phosphorus CASRN 7723-14-0

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Rats, mice, and rabbits exposed to unformulated pure red phosphorus smoke as ortho-phosphoric acid for 1 hour. Rat 1-hour LC₅₀ = 1.217 mg/L (1,217 mg/m³ as phosphorus) Mouse 1-hour LC₅₀ = 0.856 mg/L (856 mg/m³ as phosphorus) Rabbit 1-hour LC₅₀ = 5.337 mg/L (5,337 mg/m³ as phosphorus) Death, necrosis and inflammation in the larynx and trachea, pulmonary congestion, hemorrhage, edema, pneumonitis, congestion in liver and kidney (rats, mice guinea pig), cortical necrosis in kidney (mice).	EPA, 2010	Reported in a secondary source; inhalation toxicity to the red phosphorous smoke may be the result of exposure to the phosphoric acid that is generated by combustion of the smoke generating device used to make the aerosol.
		Guinea pigs exposed to RP-BR smoke at 120-2,277 mg/L (2,277 mg/m³) for 5-150 minutes. Death, respiratory distress	EPA, 2010	Reported in a secondary source.
		Mild histological changes in the respiratory tract of rabbits and rats (abnormalities in the larynx and trachea, alveolitis, frank pneumonia) exposed to pyrotechnic mixtures containing red phosphorus.	Marrs, 1984	Adequate. Histological effects seem to be a result of orthophosphoric acid aerosol.
		Reversible symptoms of respiratory distress in workers exposed to 0.1-0.7 mg/L (100-700 mg/m³) red phosphorus smoke for <15 minutes.	EPA, 2010	Reported in a secondary source.

Red Phosphorus CASRN 7723-14-0

Red Phosphorus CASRN 7723-14-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Carcinogenicity		LOW: Estimated not to have potential for carcinogenicity based on expert judgment. Red phosphorus is not listed as a known carcinogen by the International Agency for Research on Cancer (IARC), National Toxicology Program, EPA or California Proposition 65; however, no long-term carcinogenicity studies were located for red phosphorus smoke.		
	OncoLogic Results	Low potential for carcinogenicity. (Estimated)	Expert judgment	Estimated based on expert judgment.
	Carcinogenicity (Rat and Mouse)			
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		MODERATE: Uncertain potential for mutagenicity based on expert judgment. There is a lack of gene mutation data, genotoxic effects cannot be ruled out. Negative results for both chromosomal aberrations and gene mutation assays are required for a categorization of Low.		
	Gene Mutation <i>in vitro</i>	Uncertain potential for mutagenicity. (Estimated)	Expert judgment	Estimated based on expert judgment.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>			No data located.
	Chromosomal Aberrations <i>in vivo</i>	Micronucleus test in rat bone marrow polychromatic and normachromatic red blood cells. Weak clastogenic effect in both bone marrow and red blood cells following exposure to 1,000 mg/m ³ for 2 weeks.	NRC, 1997; Maine DEP, 2007	Reported in secondary sources.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: Estimated not to have potential for reproductive effects based on expert judgment. No adequate data located.		
	Reproduction/ Developmental Toxicity Screen	Low potential for reproductive effects. (Estimated)	Expert judgment	Estimated based on expert judgment.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects	Sprague Dawley rats exposed to RP-BR smoke at 132 or 1,186 mg/m³ 5 days/week for 10 weeks. No dominant lethal or single generation reproductive effects. No effects on testicular toxicity; however, the fixative used to judge histopathology was not clear. NOAEL = not established	NRC, 1997	Reported in a secondary source; limited details provided on specific reproductive/fertility parameters measured in the study.
Developmental Effects		LOW: Estimated not to have potential for developmental effects based on expert judgment. No adequate experimental data were located.		
	Reproduction/ Developmental Toxicity Screen	Low potential for developmental effects. (Estimated)	Expert judgment	Estimated based on expert judgment.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Pregnant Sprague Dawley rats exposed to RP-BR smoke at 0.132 or 1.183 mg/L (132 or 1,186 mg/m³) 5 days/week on gestation days 6-15. No dose-related increases in malformations or variations. In a single-generation using same exposure concentrations, decrease in birth weight on PND 1 for rats in the 1.183 mg/L group (recovered on PDNs 14 and 21).	NRC, 1997	Reported in a secondary source; developmental endpoints were not fully evaluated.
	Prenatal Development			No data located.
	Postnatal Development			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Neurotoxicity		LOW: Estimated not to have potential for neurotoxicity based on expert judgment. Exposure to red phosphorus/butyl rubber (RB-BR) aerosols increased locomotor activity in rats with incomplete recovery post-exposure.		
	Neurotoxicity Screening Battery (Adult)	Low potential for neurotoxicity. (Estimated)	Expert judgment	Estimated based on expert judgment.
		Sprague Dawley rats exposed to RP-BR aerosols at 400–1,200 mg/m ³ 2.25 hour/day, 4 days/week for 4 weeks; increased motor activity with incomplete recovery after 2 weeks (M). LOAEL = 0.4 mg/L	NRC, 1997	Reported in a secondary source; limited details provided.
	Developmental Neurotoxicity	Phosphorus is classified as a potential developmental neurotoxicant on the Clean Production Action Red List.	Grandjean and Landrigan, 2006	It is unclear if the data pertain to red phosphorus or white phosphorus, which is more toxic.
Repeated Dose Effects		LOW: Estimated not to have potential for repeated dose effects based on professional judgment. Experimental toxicity values located are based on inhalation exposure to a pyrotechnic mixture of red phosphorus- and red phosphorus/butyl rubber (RP-BR) smoke and not solely red phosphorous; reported toxicity in studies using the RP-BR mixtures as the test substance cannot be specifically attributed to red phosphorus.		
		Low potential for repeated dose effects. (Estimated)	Professional judgment	Estimated based on professional judgment.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Female Portan-strain mice, female Wistar rats and female Dunkin-Hartley guinea pigs exposed to a pyrotechnic mixture of red phosphorus smoke 1 hour/day, 5 days/week for 180 or 200 exposures. Concentrations: 15 and 130 mg/m³ (0.015–0.13 mg/L) Over 50% of mice died in each dose group; 80% of rats died in the high dose group; 38% of guinea pigs died in the low dose group and all died during or immediately after exposure to the high dose (death appeared due to pulmonary congestion). Depressed growth at both doses (mice, rats). Increased incidence of aggregates of macrophages containing granules in the lungs (mice); severe congestion in the lungs (guinea pigs), though no dose-related changes in rat lungs. Other findings: renal disease (mice, rats, guinea pigs), chronic interstitial nephritis (mice, guinea pigs), nephropathy (rats). LOAEL = 0.015 mg/L	Marrs et al., 1989	Adequate, guideline study; the test substance for this study was a pyrotechnic mixture of red phosphorus smoke; the toxicity reported cannot be attributed to any one component of the mixture including red phosphorus.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Rats (60/group) were exposed to RP-BR smoke at 0, 22, and 165 mg/m³ (0.022, 0.165 mg/L) for 12 weeks (8 minutes/day, 5 days/week). Reddening and swelling of the eyelids that subsided at study termination.	NRC, 1997	Reported in a secondary source; limited study details provided.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Rats (Sprague Dawley and Fisher 344), mice (Swiss and A-strain), guinea pigs and rabbits were exposed to 8-43 mg/m³ (low exposure) or 80-288 mg/m³ (high exposure) RP-BR 5 days/week for 12 weeks. Daily average exposures were 22 and 165 mg/m³ (0.022 and 0.165 mg/L) for low and high concentrations, respectively. Increased breathing rate (rats); histological changes in the lungs, trachea, upper respiratory tract and other organs (rats, mice). Authors concluded that these changes were not related to the exposure (sporadic, not unlike what was observed in controls). Morphological lesions in the lung, trachea, nasal turbines, liver, kidney, heart, testes, ovaries, urinary bladder and other organs, however these changes were also seen in controls (guinea pigs, rabbits). NOAEL: 0.165 mg/L (165 mg/m³) LOAEL: not established as highest concentration tested did not produce adverse effects.	NRC, 1997	Reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Sprague-Dawley rats were exposed to RP-BR aerosols at 400-1,200 mg/m³ for 2.25 hour/day, 4 days/week for 4 weeks. Wheezing, labored breathing (males at high dose); decreased body weight and food consumption that returned to normal during 14-day recovery period; Pulmonary edema (resolved during recovery); terminal bronchial fibrosis (400 mg/m³) that did not exhibit recovery during the observation period. LOAEL = 0.4 mg/L (based on terminal incidences of bronchial fibrosis)	NRC, 1997	Reported in a secondary source; limited study details provided.
	Sprague-Dawley (males only) exposed to RP-BR smoke at 50, 180, 300, 750 and 1,200 mg/m³ for 13 weeks. Most of the animals died during the first 2 weeks of exposure. Decrease in body weight (750 and 1,200 mg/m³); 10.8% spontaneous death or in moribund state (1,200 mg/m³); congestion/hemorrhage in lungs; terminal bronchiolar fibrosis and erosions of the laryngeal mucosa with deposition of fibrin on the surface. No deaths at 300 mg/m³ or less. NOAEL: 0.05 mg/L (50 mg/m³) LOAEL: 0.18 mg/L (180 mg/m³) based on incidence of terminal bronchiolar fibrosis	NRC, 1997	Reported in a secondary source.

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Red Phosphorus CASRN 7723-14-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Sprague Dawley rats exposed to RP-BR aerosols at 400-1,200 mg/m³ 2.25 hours/day, 4 days/week for 4 weeks. Decreased cholesterol and blood urea nitrogen (BUN) at (400 mg/m³, female; 750 mg/m³, male). Increased triglycerides (400 mg/m³, female). Female rats exposed to 1,000 mg/m³ (1 mg/L) had significant decreases in cholesterol and triglycerides and those exposed to 750 mg/m³ (0.75 mg/L) had decreased BUN after the recovery period. LOAEL = 0.4 mg/L (based on decreased cholesterol and BUN in female rats)	NRC, 1997	Reported in a secondary source; limited study details provided.
	Immune System Effects	Low potential for immunotoxicity (Estimated)	Expert judgment	Estimated based on expert judgment.
		Sprague Dawley rats exposed to RP-BR aerosols at 400–1,200 mg/m³ 2.25 hours/day, 4 days/week for 4 weeks. Decreased white blood cell count in males and increased blood lymphocytes in females at 750 mg/m³. Decreased activity of plasma membrane-associated extoenzyme 5'-nucleotidase in macrophages at 750 mg/m³. Decreased alkaline phosphatase in macrophages after 14-day recovery period (male).	NRC, 1997	Reported in a secondary source; limited study details provided.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Sprague Dawley rats exposed to RP-BR aerosols 2.25 hour/day, 4 days/week for 13 weeks. Increased ATP levels at 300 mg/m ³ ; decreased activity of 5'-nucleotidase at 750 mg/m ³ .	NRC, 1997	Reported in a secondary source; limited study details provided.
Skin Sensitization		LOW: Based on experimental data showing a lack of sensitization in guinea pigs.		
	Skin Sensitization	Not sensitizing, guinea pigs	Maine DEP, 2007	Reported in a secondary source, data are for red phosphorus; limited study details provided.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		MODERATE: Exposure to red phosphorus may cause corneal injury.		
	Eye Irritation	May cause corneal injury, rabbit (development of numerous fine blood vessels, dilation)	HSDB, 2011	Reported in a secondary source.
		Conjunctivitis, rats (1,813 mg/m ³ for 180 minutes or 1,128 mg/m ³ for 60 minutes) and dogs (1,882 mg/m ³ for 240 minutes)	NRC, 1997; EPA, 2010	Reported in secondary sources.
		Exposure to red phosphorus smoke. Symptoms resolved within 3 days post-exposure.		
		Negative, rabbit (100 mg)	NRC, 1997	Reported in a secondary source.
		Reversible irritation of the eyes and mucous membranes in workers exposed to 0.1-0.7 mg/L (100-700 mg/m ³) red phosphorus smoke for <15 minutes.	EPA, 2010	Reported in a secondary source.
Dermal Irritation		MODERATE: Prolonged contact with red phosphorus may cause skin irritation. Red phosphorus was not a skin irritant in guinea pigs.		
	Dermal Irritation	Negative, guinea pigs (0.5 g on application site)	NRC, 1997	Reported in a secondary source.

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Red Phosphorus CASRN 7723-14-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Severe irritation, rabbits Application of RP-BR residue	NRC, 1997	Reported in a secondary source; substance tested was a commercial material comprised of a combination of red phosphorus with butyl/rubber.
		Prolonged or repeated contact may cause skin irritation	Maine DEP, 2007	Reported in a secondary source; information originally reported in a MSDS for red phosphorus; no study details were provided.
Endocrine Activity		Estimated not to have potential for endocrine activity based on expert judgment.		
		Low potential for endocrine activity (Estimated)	Expert judgment	Estimated based on expert judgment.
Immunotoxicity		Estimated not to have potential for immunotoxicity based on expert judgment. Exposure to red phosphorus/butyl rubber (RP-BR) aerosols may cause decreases in white blood cell and lymphocyte counts, decreased activity of 5'nucleotides in macrophages, and increased ATP activity.		
	Immune System Effects	Low potential for immunotoxicity (Estimated)	Expert judgment	Estimated based on expert judgment.
		Sprague Dawley rats exposed to RP-BR aerosols at 400–1,200 mg/m ³ 2.25 hours/day, 4 days/week for 4 weeks.	NRC, 1997	Reported in a secondary source; limited study details provided.
		Decreased white blood cell count in males and increased blood lymphocytes in females at 750 mg/m ³ .		
		Decreased activity of plasma membrane-associated extoenzyme 5'-nucleotidase in macrophages at 750 mg/m ³ . Decreased alkaline phosphatase in macrophages after 14-day recovery period (male).		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Sprague Dawley rats exposed to RP-BR aerosols 2.25 hour/day, 4 days/week for 13 weeks. Increased ATP levels at 300 mg/m ³ ; decreased activity of 5'-nucleotidase at 750 mg/m ³ .	NRC, 1997	Reported in a secondary source; limited study details provided.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Experimental LC₅₀ values are higher than the water solubility of the test substance; no effects at saturation (NES) can be assigned.		
Fish LC₅₀		96-hour LC ₅₀ = 33 mg/L (Experimental)	ERMA	Reported in a secondary source; limited study details provided. Effect level higher than the water solubility therefore NES can be predicted.
Daphnid LC₅₀		LC ₅₀ = 10.5 mg/L (Experimental)	ERMA	Reported in a secondary source; limited study details provided. Effect level higher than the water solubility therefore NES can be predicted.
		48-hour LC ₅₀ = 1,051 mg/L (Experimental)	Maine DEP, 2007	Reported in a secondary source; limited study details provided. Effect level higher than the water solubility therefore NES can be predicted.
Green Algae EC₅₀		ECb ₅₀ = 9.5 mg/L (Experimental)	ERMA	Reported in a secondary source; limited study details provided. It is not clear which allotrope of phosphorous was used in this study. Effect level higher than the water solubility therefore NES can be predicted.

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Red Phosphorus CASRN 7723-14-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Chronic Aquatic Toxicity		LOW: Experimental toxicity value is higher than the water solubility of the test substance; NES can be assigned.		
Fish ChV		<i>Pimephales promelas</i> 30-day NOEC) = 0.007 mg/L (0.7 µg/L) (Experimental)	ERMA	Reported in a secondary source; limited study details provided. Effect level higher than the water solubility therefore NES can be predicted.
Daphnid ChV				No data located.
Green Algae ChV				No data located.
ENVIRONMENTAL FATE				
Transport		The low water solubility, relatively low vapor pressure and estimated K_{oc} of >30,000 indicate that red phosphorus will be relatively immobile in the environment and will partition primarily to soil and sediment.		
	Henry's Law Constant (atm-m³/mole)			This inorganic compound is not amenable to available estimation methods.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated)	Professional judgment; 2004	Cutoff value for non-mobile compounds. This inorganic compound is not amenable to available estimation methods.
	Level III Fugacity Model			Not all input parameters for this model were available for it to be run for this inorganic compound.
Persistence		HIGH: Red phosphorus is estimated to display high persistence in the environment. Elemental red phosphorus is relatively nonreactive under typical environmental conditions. Measured data indicate that red phosphorus will slowly undergo hydrolysis under environmental conditions (<3% in 4 months) and will eventually convert to phosphine and hypophosphorous acid. Subsequent oxidation of these hydrolysis products will lead to the formation of phosphoric oxides and acids.		
Water	Aerobic Biodegradation			No data located; elemental inorganic materials are outside the domain of the EPI estimation models.
	Volatilization Half-life for Model River			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Volatilization Half-life for Model Lake			No data located.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Not a significant fate process (Estimated)	Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	0.7% after 24 hours, 3.7% after 700 hours (Measured)	Walz and Beard, 2000	These nonguideline studies indicate that hydrolysis will occur slowly under environmental conditions.
		Red phosphorus conversion rate of 2.7% over 4 months at room temperature (Measured)	Walz and Beard, 2000; Stuer-Lauridsen et al., 2007	
		Red phosphorus does not dissolve readily in water; atoms on the surface of the amorphous solid react slowly with water initially forming phosphine (7803-51-2) and hypophosphorous acid (6303-21-5). (Measured)	Leisewitz et al., 2001	
Environmental Half-life				No data located.

Red Phosphorus CASRN 7723-14-0				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Bioaccumulation		LOW: Due to the large size, water insolubility and amorphous nature of this inorganic substance, elemental phosphorous has a low potential for bioconcentration or bioaccumulation as it is unlikely to pass through biological membranes.		
	Fish BCF	<100 (Estimated)	Professional judgment	Red phosphorus has very low water solubility. It is also a large, amorphous solid and is unlikely to pass through biological membranes.
	BAF			No data located.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Resorcinol Bis-Diphenylphosphate; RDP

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance, including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

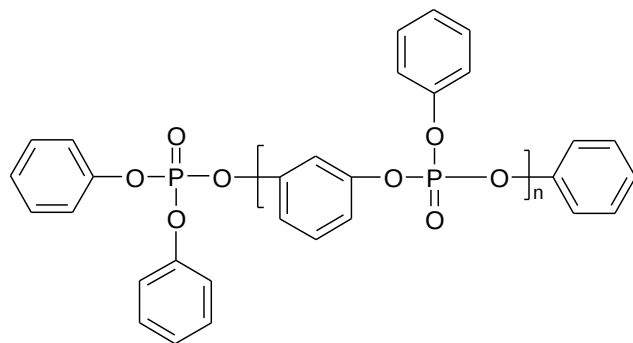
[‡] The highest hazard designation of any of the oligomers with MW <1,000.

[§] Based on analogy to experimental data for a structural similar compound.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Resorcinol Bis-Diphenylphosphate; RDP	125997-21-9	L	M [§]	L	L	M	M	M	L		L	VL	VH	VH	M	H [‡]

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Resorcinol Bis-Diphenylphosphate; RDP



n = 1-7

CASRN: 125997-21-9

MW:

574.46 (n=1; CASRN 57583-54-7);

822.64 (n=2; CASRN 98165-92-5)

MF:

C₃₀H₂₄O₈P₂ (n=1; CASRN 57583-54-7);

C₄₂H₃₃O₁₂P₃ (n=2; CASRN 98165-92-5)

Physical Forms:

Neat: Liquid

Use: Flame retardant

SMILES: c1ccccc1OP(=O)(Oc2ccccc2)Oc3ccccc3OP(=O)(Oc4ccccc4)Oc5ccccc5 (CASRN 57583-54-7; n=1);

c1(OP(=O)(Oc2ccccc2)Oc2ccccc2)cc(OP(=O)(Oc2ccccc2)Oc2ccccc2)ccc2)Oc2ccccc2)ccc1 (CASRN 98165-92-5; n=2)

Synonyms: Phosphoric trichloride, polymer with 1,3-benzenediol, phenyl ester; Fyrolflex RDP; Plamtar-RDP; RBBPP; Reofos RDP; Resorcinol bis (biphenyl phosphate); Phosphoric acid, 1,3-phenylene tetraphenyl ester; Phosphorous oxychloride, reaction product with resorcinol and phenol; Resorcinol bis-diphenylphosphate; Tetraphenyl resorcinol diphosphate

Chemical Considerations: This alternative is a polymer; the n=1 and n=2 oligomers are those with a MW <1,000. EPI v4.0 was used to estimate physical/chemical and environmental fate values due to an absence of experimental data. The higher MW oligomers are anticipated to behave similar to the oligomer where n=2.

The material used by industry for flame retardant applications is most likely the polymeric material with CAS number 125997-21-9, although the CAS number for the discrete organic where n=1, 57583-54-7 (Phosphoric acid, P,P'-1,3-phenylene P,P',P'-tetraphenyl ester), has been used interchangeably with 125997-21-9 in the publicly available literature.

Polymeric: Yes	
Oligomers: The major component of this polymer is the oligomer where n=1, which typically comprises 95-99% of the mixture (EPA, 2010a). The balance is made up of higher oligomers (n=2, 3, etc.) and a triphenyl phosphate impurity (1-5% w/w).	
Metabolites, Degradates and Transformation Products: Hydroxy-RDP, dihydroxy-RDP, resorcinol diphenyl phosphate, and hydroxyl-resorcinol diphenyl phosphate, resorcinol (108-46-3), resorcinol conjugates, resorcinylic glucuronide and resorcinylic sulfate were identified as metabolites (Freudenthal et al., 2000). Environmental degradation of RDP has been demonstrated in experimental studies (IUCLID, 2001); however the degradates have not been identified. Degradation of RDP by sequential dephosphorylation could produce phenol (CASRN 108-95-2), diphenyl phosphate (CASRN 838-85-7), or resorcinol (CASRN 108-46-3). The importance of dephosphorylation relative to possible competing pathways has not been demonstrated in a published study.	
Analog: Aryl phosphates and other confidential analogs Endpoint(s) using analog values: Carcinogenicity and neurotoxicity	Analog Structure: The analogs are structural classes or confidential and cannot be suitably represented here.
Structural Alerts: Organophosphates, neurotoxicity (EPA, 2011a).	
Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community (EEC) & IUCLID (Pakalin et al., 2007).	
Hazard and Risk Assessments: An assessment was completed for resorcinol bis-diphenylphosphate by Washington State in 2006 (Laflamme, 2006).	

Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	-12 (Measured)	AkzoNobel, 1998; Bayer, 2002; Weil, 2001; Supresta, 2011	The reported values are for the pour point of the commercial polymeric mixture, which is a liquid at room temperatures.
	-13 (Measured)	Great Lakes, 2003	
	-16.7 (Measured)	AkzoNobel, 1998	
Boiling Point (°C)	300 (Measured)	UBA, 2001a, 2003	Decomposition may occur before the boiling point is reached.
	>300 (Measured)	AkzoNobel, 1998; Bayer, 2002; UBA, 2001b; Supresta, 2011	
	>300 decomposes (Measured)	UBA, 2001b; Great Lakes, 2003	
	370 decomposes (Measured)	Supresta, 2011	
	>400 decomposes (Measured)	Bayer, 2002	
	38 at 138 Pa (Measured)	UBA, 2001a; 2001b; 2003	
Vapor Pressure (mm Hg)	1.9×10^{-5} at 20°C (Measured)	EPA, 2010	The reported experimental data is for the commercial polymeric mixture.
	0.007 at 38°C (Measured)	UBA, 2001a, 2001b, 2003	
	0.28 (Measured)	Supresta, 2011	
	<0.075 at 38°C (Measured)	IUCLID, 2001	
Water Solubility (mg/L)	1.05 mg/L at 20°C (Measured)	EPA, 2010a	The reported experimental data is for the commercial polymeric mixture.
Log K_{ow}	4.93 (Measured)	EPA, 2010a; Wildlife International Ltd., 2003	The reported experimental data is for the commercial polymeric mixture.
	4.9 (Measured)	ICL Industrial, 2009	
Flammability (Flash Point)	>230°C (Measured)	ICL Industrial, 2009	Adequate.
	>240°C (Measured)	Chang Chun, no date	
	302°C (Measured)	Bayer, 2002	
Explosivity	Not explosive (Measured)	IUCLID, 2001; ICL Industrial, 2009	Insufficient study details to assess the quality of this value.
Pyrolysis			No data located.

Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pH		Not applicable	Professional judgment	This polymer does not contain functional groups that would be expected to ionize.
pK _a		Not applicable	Professional judgment	This polymer does not contain functional groups that would be expected to ionize.
HUMAN HEALTH EFFECTS				
Toxicokinetics		Resorcinol bis-diphenylphosphate was readily absorbed via the oral route and was absorbed to a lesser extent following dermal exposure. Metabolism was extensive with metabolites excreted in feces, urine, and in expired air as CO ₂ .		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Studies were conducted on rats, mice and monkeys following exposure to radiolabeled tetraphenyl resorcinol diphosphate (purity: 99%) via intravenous injection, oral, inhalation, and dermal routes of exposure. Blood, urine and feces were collected for approximately 7 days and metabolites were isolated and characterized; the brain, mesenteric fat, kidneys, liver, lungs, tests/ovaries and spleen were collected from rats at time of necropsy. RDP was absorbed and was extensively metabolized; Metabolism was consistent between species, sexes, and individual animals; Excretion occurred primarily in the feces and then urine. The major metabolites in the feces included resorcinol diphenylphosphate	Freudenthal et al., 2000; UK Environment Agency, 2009	Nonguideline study.

Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		(RDP half ester), hydroxy-RDP half ester, dihydroxy-RDP, and hydroxy-RDP; Metabolites found in urine included resorcinol, resorcinyl glucuronide, and resorcinyl sulfate.		
		Rats and mice were administered a single intravenous dose of 100 mg/kg radiolabeled tetraphenyl resorcinol diphosphate (purity: 99%). In rats, 13%, 45%, and 7% of the administered intravenous dose was excreted in urine, feces, and expired air (as CO₂), respectively, 7 days after exposure. In monkeys, 24% and 26% was excreted in urine and feces, respectively; expired air was not measured. There were no data reported for mice following intravenous exposure.	Freudenthal et al., 2000; UK Environment Agency, 2009	Nonguideline study.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Rats were exposed to radiolabeled tetraphenyl resorcinol diphosphate (purity: 99%) via a single oral gavage dose of 100 mg/kg. 83% of the administered dose of RDP was absorbed; 80% of the absorbed radiolabelled dose was excreted in the feces as metabolites, 7% was excreted in the urine and 5% was excreted as CO₂ in expired air. Un-metabolized RDP was found in the feces following oral exposure, indicating that some of the administered oral dose was not absorbed through the gastrointestinal route.	Freudenthal et al., 2000; UK Environment Agency, 2009	Nonguideline study.
		Rats and monkeys were administered a dermal dose of 100 mg/kg radiolabelled ¹⁴C-tetraphenyl resorcinol diphosphate (purity: 99%) for 6 hours. 20% of RDP was absorbed in the systemic circulation in rats following the six-hour exposure and <10% was absorbed in monkeys. 7 days post-exposure, rats eliminated 7, 32, and 1% of administered dose in the urine, feces, and expired air, respectively. 1% of the administered dose was eliminated in expired air in monkeys after 7 days; the remaining absorbed dose was excreted by day 28.	Freudenthal et al., 2000; UK Environment Agency, 2009	Nonguideline study.

Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Rats were exposed to radiolabeled tetraphenyl resorcinol diphosphate via nose-only inhalation for 6 hours at a target delivered dose of 100 mg/kg. 60% of RDP was excreted in the feces in males and 52% in females following exposure. 10% in males and 7% in females was excreted in the urine.	Freudenthal et al., 2000; UK Environment Agency, 2009	Nonguideline study; doses are not reported in standard mg/L units; the authors state that actual retained dose in the lung cannot be measured accurately for the inhalation study.
Acute Mammalian Toxicity		LOW: Based on an oral LD₅₀ >5,000 mg/kg-bw and a dermal LD₅₀ >2,000 mg/kg-bw in rats. The acute inhalation study in rats produced no deaths at the highest dose tested. The LC₅₀ of >4.14 mg/L could not be used to evaluate the hazard designation because it is uncertain at which dose the LC₅₀ would occur; the criteria threshold for Low is 5 mg/L for mists. Though unlikely, it is uncertain if the LC₅₀ could occur between 4.15 mg/L and 5.0 mg/L (a Moderate hazard designation).		
Acute Lethality	Oral	Rat Oral LD ₅₀ >5,000 mg/kg-bw	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture.
	Dermal	Rat Dermal LD ₅₀ >2,000 mg/kg-bw	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture.
	Inhalation	Rat Inhalation (aerosol, nose-only) LC ₅₀ >4.14 mg/L	EPA, 2010	The study is a quality guideline study reported in a secondary source; It cannot be used to determine a hazard designation because there were no effects at the highest concentrations tested (4.14 mg/L); From this data, it cannot be determined if effects happened at 4.15 mg/L (Moderate) or at a concentration that can be considered Low; therefore, this study cannot be used to determine a hazard designation.

Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Carcinogenicity		MODERATE: Estimated to have uncertain potential for carcinogenicity based on analogy to aryl phosphate analogs and professional judgment.		
	OncoLogic Results			Structure could not be evaluated by OncoLogic.
	Carcinogenicity (Rat and Mouse)	Uncertain potential for oncogenicity (Estimated by analogy)	Professional judgment	Estimated by analogy to aryl phosphates.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		LOW: Resorcinol bis-diphenylphosphate did not cause gene mutations or chromosomal aberrations <i>in vitro</i> and did not produce an increase in micronuclei in mice <i>in vivo</i>.		
	Gene Mutation <i>in vitro</i>	Negative in <i>Salmonella typhimurium</i> (strains not indicated) with and without metabolic activation at concentrations up to 5,000 µg/plate. No cytotoxicity was evident.	Pakalin et al., 2007; EPA, 2010	Guideline study. Data are for the commercial polymeric mixture.
		Negative in <i>Escherichia coli</i> (strains not indicated) with and without metabolic activation at concentrations up to 5,000 µg/plate. No cytotoxicity was evident.	Pakalin et al., 2007; EPA, 2010	Guideline study. Data are for the commercial polymeric mixture.
				No data located.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative in chromosomal aberration test (cultured human lymphocytes) with and without metabolic activation at concentrations up to 625 µg/mL. Cytotoxicity data not indicated.	Pakalin et al., 2007; EPA, 2010	Guideline study. Data are for the commercial polymeric mixture.
	Chromosomal Aberrations <i>in vivo</i>	Negative in mammalian erythrocyte micronucleus test (Swiss mice) following a single oral dose of 5,000 mg/kg-bw.	Pakalin et al., 2007; EPA, 2010	Guideline study. Data are for the commercial polymeric mixture.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Negative in mammalian erythrocyte micronucleus test (mice) following single oral dose of 500 mg/kg bw.	UK Environment Agency, 2009	Study details reported in a secondary source; Study was conducted in accordance with good laboratory practice (GLP) and Organisation of Economic Cooperation and Development (OECD) Guideline 474.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: Experimental data for resorcinol bis-diphenylphosphate indicate no adverse effects on reproductive performance or fertility parameters at doses up to 1,000 mg/kg-day (highest dose tested) in a two generation dietary study in rats. There may be potential for reproductive toxicity based on analogy to confidential analog.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.

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Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Reproduction and Fertility Effects	Two generation dietary reproduction study in rats. Sprague-Dawley rats (30/sex/dose) were fed 0, 50, 500, or 1,000 mg/kg/day resorcinol bis-diphenylphosphate in the diet for 10 weeks. No clinical signs of toxicity. No effects on litter survival. No adverse effects on any reproductive or fertility parameter measured. No treatment-related lesions in any reproductive organ. NOAEL (parental systemic and reproductive toxicity) = ~ 1,000 mg/kg bw/day LOAEL: not established as highest concentration tested did not produce adverse effects.	Pakalin et al., 2007; EPA, 2010	Guideline study. Data are for the commercial polymeric mixture.
		Potential for reproductive toxicity; no pregnancies (1,000 mg/kg/day); reduced litter size and weight (250 mg/kg/day) NOEL = 50 mg/kg-day LOEL = 250 mg/kg/day (Estimated by analogy)	Professional judgment; Confidential study	Estimated by analogy to confidential analog.
Developmental Effects		MODERATE: Based on a NOAEL of 50 mg/kg bw-day in a two generation dietary reproduction study in rats. Adverse effects included delayed vaginal opening and preputial separation at a dose of 500 mg/kg bw-day. No adverse developmental effects were observed in rabbits following oral administration of resorcinol bis-diphenylphosphate at doses up to 1000 mg/kg bw-day.		
	Reproduction/ Developmental Toxicity Screen			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen	Two generation dietary reproduction study in rats. Sprague-Dawley rats (30/sex/dose) were fed 0, 50, 500, or 1,000 mg/kg/day resorcinol bis-diphenylphosphate in the diet for 10 weeks. Vaginal opening and preputial separation were delayed at 500 and 1,000 mg/kg, but effect was considered secondary to reduction of body weight in F₁ generation during week 1 (treated animals had decreased body weights compared to controls during week 1, reportedly due to an initial aversion to taste of diet). NOAEL: 50 mg/kg bw-day (for vaginal opening and preputial separation) LOAEL: 500 mg/kg bw-day	Pakalin et al., 2007; EPA, 2010	Guideline study. Data are for the commercial polymeric mixture.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Developmental oral gavage study in rabbits. Pregnant New Zealand white rabbits (27/group) were dosed with 0, 50, 200 or 1,000 mg/kg resorcinol bis-diphenylphosphate by oral gavage on gestation days (GDs) 6-28. No clinical signs of toxicity. No adverse effects on maternal food consumption, body weight gain or organ weights. No adverse effects on fetal body weights, viability, or any developmental endpoint measured. NOAEL (maternal and developmental toxicity) = 1,000 mg/kg LOAEL: not established as highest concentration tested did not produce adverse effects	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Prenatal Development	Pregnant rabbits; oral gavage; GD 6-23; 0, 50, 200 or 1,000 mg/kg test material No deaths or clinical signs of toxicity. No significant effect on body weight, body weight gain, food consumption or organ weight. No significant effect on litter weight or pup viability. No gross external, skeletal or soft tissues malformations or anomalies. NOAEL = 1,000 mg/kg-day (highest dose tested) LOAEL = Not established	UK Environment Agency, 2009	Study details reported in a secondary source; Study conducted according to GLP
	Postnatal Development			No data located.
Neurotoxicity		MODERATE: Based on a 28-day inhalation LOAEL of 0.5 mg/L for inhibition of plasma ChE in rats (NOAEL = 0.1 mg/L); criteria values are tripled for chemicals evaluated in 28-day studies; the LOAEL of 0.5 mg/kg-day falls within the Moderate hazard criteria (0.06 - 0.6 mg/L).		
	Neurotoxicity Screening Battery (Adult)	28-day oral (gavage) study NOAEL = 1,000 mg/kg (Estimated by analogy)	Submitted confidential study; Professional judgment	Estimated based on analogy to phosphoric acid, mixed esters with [1,1'-bisphenyl-4,4'-diol] and phenol (CASRN 1003300-73-9)

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Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		28-day inhalation study in rats; 0, 0.1, 0.5 and 2.0 mg/L (aerosol); Significant inhibition of plasma ChE (0.5 and 2.0 mg/L). No clinical signs suggestive of neurotoxic effect and ChE was not affected after study termination NOAEL : 0.1 mg/L LOAEL : 0.5 mg/L (plasma ChE inhibition)	UK Environment Agency, 2009; Heinrich et al., 2000	Study details reported in a secondary source; study was not designed to assess all neurological parameters; criteria values are tripled for chemicals evaluated in 28-day studies; the LOAEL of 0.5 mg/kg-day falls within the Moderate hazard criteria (0.06 - 0.6 mg/L).
		28-day oral (gavage) study in mice; 0, 500, 1,500, 5,000 mg/kg Dose-related decrease in plasma ChE compared to controls, which was no longer apparent after the 60 day recovery period. No NOAEL/LOAEL determined	UK Environment Agency, 2009	Study details reported in a secondary source; study was not designed to assess all neurological parameters; cannot rule out all neurotoxicity.
		Repeated Dose Effects		
Repeated dose effects		28-day oral study, rats Potential for liver toxicity. NOEL = 300 mg/kg/day (Estimated based on analogy)	Professional judgment; Confidential study	Estimated based on analogy to confidential analog.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	In a 4-week inhalation study Sprague-Dawley rats (10/sex/group) were exposed (aerosol, nose only) to 0, 100, 500 or 2,000 mg/m³ (0, 0.1, 0.5, or 2 mg/L) resorcinol bis-diphenylphosphate. No deaths or clinical signs of toxicity. Decreased body weight and food consumption in males and significant inhibition of plasma cholinesterase in females at 2,000 mg/m³. White foci in the lungs at 2,000 mg/m³ and alveolar histiocytosis at 500 and 2,000 mg/m³. Although lung changes are relevant, they were not considered to be a reflection of a specific toxic response to resorcinol bis-diphenylphosphate; these changes are characteristic of exposure to non-cytotoxic water-insoluble materials. No other gross or microscopic pathology in any organ. NOAEC: 100 mg/m³ (0.1 mg/L) LOAEC: 500 mg/m³ (0.5 mg/L) based on alveolar histiocytosis	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Immune System Effects	Negative, oral gavage study in mice. Female B6C3F1 mice (50/group) were exposed via oral gavage to 0, 500, 1,500, or 5,000 mg/kg-day resorcinol bis-diphenylphosphate for 28 days. No deaths, clinical signs of toxicity, or effects on body or organ weights. No adverse histopathological changes or necropsy findings. No treatment-related changes in peritoneal cell numbers or cell types, peritoneal macrophage phagocytic activity or host susceptibility to infection. No adverse effect on splenic natural killer cell activity, lymphocyte blastogenesis, or antibody-forming cell function. There were significant decreases in erythrocyte cholinesterase activity and plasma pseudocholinesterase activity in all dose groups, but both enzyme activities returned to control levels at the end of the 60 day recovery period. NOAEL: 5,000 mg/kg-day LOAEL: not established, as highest dose tested did not produced adverse effects.	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture.
Skin Sensitization		LOW: Estimated not to have potential for skin sensitization based on expert judgment.		
	Skin Sensitization	No potential for skin sensitization (Estimated)	Expert judgment	Estimated by expert judgment.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.

Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Eye Irritation		LOW: Resorcinol bis-diphenylphosphate produced mild irritation in rabbit eyes; however, clearing occurred within 24 hours.		
	Eye Irritation	Rabbit, minimally irritating. 0.1 ml instilled into the left eyes of 3 rabbits produced slight conjunctival redness and chemosis that was reversible by 24 hours.	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture.
Dermal Irritation		VERY LOW: Resorcinol bis-diphenylphosphate is not a dermal irritant in rabbits.		
	Dermal Irritation	Rabbit, not irritating	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture.
Endocrine Activity		No experimental data were located to evaluate and determine if RDP affects endocrine activity. However, resorcinol, a metabolite of RDP, is listed as a suspected endocrine disruptor by the EU.		
		Resorcinol is listed as a potential endocrine disruptor on the EU Priority List of Suspected Endocrine Disruptors.	European Commission, 2012	“Potential for endocrine disruption. In vitro data indicating potential for endocrine disruption in intact organisms. Also included effects in-vivo that may, or may not, be endocrine disruption-mediated. May include structural analyses and metabolic considerations”.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Immunotoxicity		Resorcinol bis-diphenylphosphate had no effect on immunological parameters at doses up to 5,000 mg/kg-day (highest dose tested) in an oral gavage study in mice.		
	Immune System Effects	Negative, oral gavage study in mice. Female B6C3F1 mice (50/group) were exposed via oral gavage to 0, 500, 1,500, or 5,000 mg/kg-day resorcinol bis-diphenylphosphate for 28 days. No deaths, clinical signs of toxicity, or effects on body or organ weights. No adverse histopathological changes or necropsy findings. No treatment-related changes in peritoneal cell numbers or cell types, peritoneal macrophage phagocytic activity or host susceptibility to infection. No adverse effect on splenic natural killer cell activity, lymphocyte blastogenesis, or antibody-forming cell function. There were significant decreases in erythrocyte cholinesterase activity and plasma pseudocholinesterase activity in all dose groups, but both enzyme activities returned to control levels at the end of the 60 day recovery period. NOAEL: 5,000 mg/kg-day LOAEL: not established, as highest dose tested did not produced adverse effects.	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ECOTOXICITY			
ECOSAR Class			
Acute Toxicity	VERY HIGH: Based on measured EC₅₀ values for daphnia. Measured values for fish and algae are higher than the water solubility limit, suggesting no effects at saturation (NES).		
Fish LC₅₀	<i>Brachydanio rerio</i> 96-hour LC ₅₀ = 12.3 mg/L (OECD Guideline 203) (Experimental)	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture. Given that the reported value is greater than the water solubility, NES were observed for this endpoint.
	Fish 96-hour LC ₅₀ = NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES are estimated for the n=1 and higher oligomers. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Daphnid LC₅₀	<i>Daphnia magna</i> 48-hour EC ₅₀ = 0.7 mg/L (U.S. EPA OPPTS 850.1010) (Experimental)	EPA, 2010	Guideline study reported in a secondary source.
	Daphnid 48-hour LC ₅₀ = NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES are estimated for the n=1 and higher oligomers. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Other Freshwater Invertebrate LC₅₀			No data located.
Green Algae EC₅₀	<i>Pseudokirchneriella subcapitata</i> 72-hour EC ₅₀ = 48.6 mg/L (OECD Guideline 201) (Experimental)	EPA, 2010	Guideline study reported in a secondary source. Data are for the commercial polymeric mixture. Given that the reported value is greater than the water solubility, NES was observed for this endpoint.
	<i>Pseudokirchneriella subcapitata</i> 72-hour NOEC = 10 mg/L (water accommodated fraction (WAF)) 72-hour LOEC = 100 mg/L (WAF) (OECD Guideline 201) (Experimental)	UK Environment Agency, 2009	Study details reported in a secondary source. Study conducted according to GLP.
	Green algae 96-hour EC ₅₀ = NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES are estimated for the n=1 and higher oligomers. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Chronic Aquatic Toxicity	VERY HIGH: Based on an experimental 21-day NOEC 0.021 mg/L in <i>Daphnia magna</i>. Estimated ChV values suggest a High hazard with the n = 1 oligomer (phosphate esters ECOSAR class) of 0.0093 mg/L for fish.		
Fish ChV	ChV – NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES are estimated for the n=1 and higher oligomers. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Daphnid ChV	Daphnia magna 21d-NOEC = 0.021 mg/L 21-d EC ₅₀ = 0.037 mg/L Semi-static (OECD guideline 211) (Experimental)	Submitted confidential study	Reported in a submitted confidential study; Guideline study conducted according to GLP; test substance is identified as the n=1 oligomer (CASRN: 57583-54-7); it is reported that the toxicity may be a result of the presence of undissolved test substance, although toxicity by the dissolved substance could not be ruled out.
	ChV – NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES are estimated for the n=1 and higher oligomers. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

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Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Green Algae ChV		ChV – NES (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Estimates were performed on oligomers of the polymeric mixture that have a MW <1,000; NES are estimated for the n=1 and higher oligomers. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
ENVIRONMENTAL FATE				
Transport		The environmental fate is described for the oligomer where n=1, which is the primary component of the commercial product. Based on the Level III fugacity models incorporating the located experimental property data, resorcinol bis-diphenylphosphate is expected to partition primarily to soil and sediment. Resorcinol bis-diphenylphosphate is expected to be immobile in soil based on its estimated K _{oc} . Leaching of resorcinol bis-diphenylphosphate through soil to groundwater is not expected to be an important transport mechanism. Estimated volatilization half-lives indicate that it will be non-volatile from surface water. Volatilization from dry surface is also not expected based on its vapor pressure. In the atmosphere, resorcinol bis-diphenylphosphate is expected to exist solely in the particulate phase, based on its estimated vapor pressure. Particulates may be removed from air by wet or dry deposition. The higher MW components of the commercial product are anticipated to behave similarly to that described above.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated for n=1 and n=2)	EPI	Cutoff value for nonvolatile compounds. Higher MW components are also expected to have Henry's Law Constant values below this cutoff.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated for n=1 and n=2)	EPI; EPA, 1999	Cutoff value for non mobile compounds according to HPV assessment guidance. Higher MW components are also expected to have K _{oc} values above this cutoff.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Level III Fugacity Model	Air: <1% (Estimated for n=1) Water = 1% Soil = 40% Sediment = 59% Air: <1% (Estimated for n=2) Water = 1% Soil = 42% Sediment = 57%	EPI	Estimates were performed on representative components of the polymer.
Persistence		MODERATE: Moderate persistence is expected for resorcinol bis-diphenylphosphate based on experimental biodegradation studies that indicate the potential for biodegradation of the commercial polymeric mixture. The commercial mixture was determined to be inherently biodegradable using the guidelines of Directive 84/449/EEC, C.6 “Biotic degradation - the Closed Bottle test” test. After 28 days, 37% biodegradation occurred and after 56 days, 66% biodegradation occurred. Resorcinol bis-diphenylphosphate oligomers (n=1 and n=2) do not contain chromophores that absorb at wavelengths >290 nm, and therefore, are not expected to be susceptible to direct photolysis by sunlight. The atmospheric half-life of resorcinol bis-diphenylphosphate oligomers are estimated to be 6.1 (n=1) and 4.1 (n=2) hours, although they are expected to exist primarily in the particulate phase in air. Enzymatic or basic hydrolysis leading to the production of phenol (CASRN 108-95-2), diphenyl phosphate (CASRN 838-85-7), and resorcinol (CASRN 108-46-3) through sequential dephosphorylation is theoretically possible but has not been demonstrated.		
Water	Aerobic Biodegradation	37% degradation after 28 days; 66% degradation after 56 days Using Directive 84/449/EEC, C.6; inherent biodegradation, 2.7 mg/L of compound in activated sludge (Measured)	IUCLID, 2001	The data is for the commercial polymeric mixture (CASRN 125997-21-9).
	Volatilization Half-life for Model River	>1 year (Estimated for n=1 and n=2)	EPI	Based on the magnitude of the estimated Henry’s Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated for n=1 and n=2)	EPI	Based on the magnitude of the estimated Henry’s Law Constant.
Soil	Aerobic Biodegradation			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Anaerobic Biodegradation	Not probable (Anaerobic-methanogenic biodegradation probability model for n=1 and n=2) (Estimated)	EPI	
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	6.1 hours (Estimated for n=1) 4.1 hours (Estimated for n=2)	EPI	
Reactivity	Photolysis	Not a significant fate process (Estimated for n=1 and n=2)	Mill, 2000; Professional judgment	The substance does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
	Hydrolysis	Half-life = 320 days at pH 7 Half-life = 32 days at pH 8 Half-life = 3 days pH 9 (Estimated for n=1) Half-life = 240-320 days at pH 7 Half-life = 24-32 days at pH 8 Half-life = 2-3 days pH 9 (Estimated for n=2)	EPI	Hydrolysis rates are expected to be pH-dependent and may be limited by the low water solubility of this compound. Under basic conditions, sequential dephosphorylation reactions may occur.

Resorcinol Bis-Diphenylphosphate CASRN 125997-21-9

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Half-life = 11 days (20°C; pH 4) Half-life = 17 days (20°C; pH 7) Half-life = 21 days (20°C; pH 9) OECD 111 (Measured)	IUCLID, 2001	Inadequate. Although reported as a guideline study, phosphate esters as a chemical class have been observed to hydrolyze more rapidly under basic pHs than under neutral or acidic conditions. The reported half-lives do not follow this trend, and are therefore suspect. Under basic conditions, sequential dephosphorylation reactions may occur.
Environmental Half-life		>180 days (Estimated for n=1 and n=2)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.
Bioaccumulation		HIGH: The estimated BCF value for the n=1 component has high potential for bioaccumulation. The higher MW oligomers that may be found in this mixture (n=2, 3, 4...) are expected to have moderate or low potential for bioaccumulation based on their large size and low solubility according to the polymer assessment literature (Boethling et al., 1997).		
	Fish BCF	1,300 (Estimated for n=1) 59 (Estimated for n=2)	EPI	
	BAF	81 (Estimated for n=1) 7 (Estimated for n=2)	EPI	
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the biomonitoring report (CDC, 2011).		

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Substituted Amine Phosphate Mixture

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (**VL**, **L**, **M**, **H**, and **VH**) were assigned based on empirical data. Endpoints in black italics (*VL*, *L*, *M*, *H*, and *VH*) were assigned using values from estimation software and professional judgment.

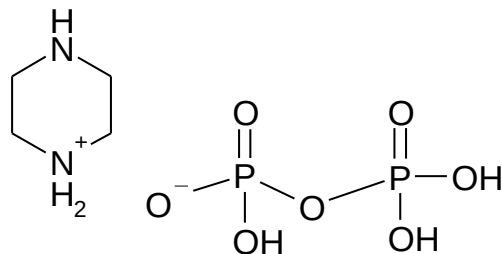
[§] Based on analogy to experimental data for a structurally similar compound.

Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Substituted Amine Phosphate Mixture ¹	Confidential	H	M	M	M	M	L	M	L	M ^s	M	VL	M	L	H	L

** Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

¹ Hazard designations are based upon the component of the salt with the highest hazard designation, including the corresponding free acid or base.

Substituted Amine Phosphate Mixture



mixture with confidential substituted amine phosphate

CASRN:

66034-17-1 (Piperazine pyrophosphate) and confidential CASRN (substituted amine phosphate)

MW: 264 (Piperazine pyrophosphate) and confidential MW (substituted amine phosphate)

MF:

$C_4H_{11}N_2^{+1} \cdot P_2O_7H_3^{-1}$ and confidential MF (substituted amine phosphate)

Physical Forms:

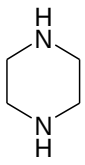
Neat: Solid

Use: Flame retardant

SMILES: This mixture containing confidential material is not amenable to the generation of a single SMILES notation.

Synonyms: ADK STABILIZER FP-2100J; ADK STABILIZER FP-2200; ADK STABILIZER FP-2200S; ADK STABILIZER FP-2400

Chemical Considerations: This alternative is a mixture. The substituted amine phosphate mixture represents the ADK Stabilizer series of commercial mixtures that are comprised of approximately 50% of piperazine pyrophosphate (Diphosphoric acid, compd. with piperazine (1:1), CAS 66034-17-1, MW=264) and a substituted amine phosphate. Piperazine pyrophosphate will dissociate into piperazine and pyrophosphate (diphosphoric acid) anions under environmental conditions and, therefore, the relevant dissociation products piperazine or pyrophosphate was used in each endpoint as appropriate. The same approach was used for the substituted amine phosphate anions. Measured or estimated values for the dissociated components were used to fill assessment data gaps as appropriate.

Polymeric: No Oligomers: Not applicable	
Metabolites, Degradates and Transformation Products: Pyrophosphoric acid (2466-09-3), Piperazine (110-85-0), glycine (56-40-6) and other confidential substances.	
Analog: Piperazine (110-85-0); and confidential analogs, piperazine-containing compounds. Endpoint(s) using analog values: Respiratory sensitization	Analog Structure:  Piperazine
Structural Alerts: Amines, potential nephrotoxins (EPA, 2011).	
Risk Phrases: Not classified by Annex VI Regulation (EC) No. 1272/2008 (ESIS, 2011).	
Hazard and Risk Assessments: None identified.	

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	>300 (Estimated)	Professional judgment	The components of this mixture are ionic compounds and are anticipated to be high melting solids. Cutoff value for high melting compounds.
Boiling Point (°C)	>270 decomposes (Measured)	Adeka-Palmarole, 2011	Product information for FP-2100J; refers to the ionic compounds in ADK stabilizers.
	>260 decomposes (Measured)	Adeka-Palmarole, 2011	Product information for FP-2200; refers to the ionic compounds in ADK stabilizers.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; EPA, 1999	Cutoff value for nonvolatile compounds according to HPV assessment guidance. Applies to both ionic solids present in the substituted amine phosphate mixture.
Water Solubility (mg/L)	Piperazine pyrophosphate: >1,000,000 (Estimated)	EPI	
	Substituted amine phosphate component: >1,000,000 (Estimated)	EPI	
	Substituted amine phosphate component: approximately 800; 900 (Measured)	Confidential MSDS, 2011; Weil, 2001	Inadequate; these reported values are inconsistent with structurally similar phosphates.
Log K_{ow}	Piperazine pyrophosphate: <-2 (Estimated)	EPI	
	Substituted amine phosphate component: <-2 (Estimated)	EPI	

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Flammability (Flash Point)		Nonflammable (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Explosivity		Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis				No data located.
pH				No data located.
pK _a				No data located.
HUMAN HEALTH EFFECTS				
Toxicokinetics		No toxicokinetic data were located for the substituted amine phosphate mixture. The substituted amine phosphate mixture is estimated to not be absorbed through the skin and absorption is expected through the lung and gastrointestinal (GI) tract. Following absorption, limited data suggest distribution throughout the GI system, liver, and kidney for the substituted amine phosphate and piperazine components. Data for the substituted amine phosphate component indicate an elimination phase half-life of 2.7 hours from plasma and 3 hours for urine. Data for the piperazine component indicate rapid elimination from blood and kidney.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Substituted amine phosphate mixture: Not absorbed from the skin, absorption through lung and GI tract. (Estimated by analogy)	Professional judgment	Based on closely related analogs with similar structures, functional groups, and physical/chemical properties.
		Substituted amine phosphate component: The elimination phase half-life calculated from plasma data was 2.7 hours, and the urinary half-life was 3.0 hours. The renal clearance was determined to be 2.5 mL/min. (Measured for the free base)	Confidential study	Nonguideline study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: Distributed to stomach, small intestine, cecum, and large intestine, and found in blood, and urine of rats. (Measured for the free base)	Confidential study	Study details reported in a secondary source.
		Piperazine: Pig, oral (gavage); peak plasma concentrations occurred 1 hour after exposure; quickly eliminated from blood. Distributed primarily to kidneys and liver; eliminated quickly from kidney, and slower from liver, skeleton, muscle, fat and skin. Low potential for bioaccumulation. (Measured for the free base)	ECHA, 2011	Study details reported in a secondary source.
Acute Mammalian Toxicity		HIGH: Using a conservative approach, acute toxicity hazard potential for the substituted amine phosphate mixture is estimated based on toxicity for inhalation exposure to the piperazine moiety in rats. The hazard is estimated to be low for oral and dermal routes of exposure to the substituted amine phosphate and piperazine components of the mixture.		
Acute Lethality	Oral	Substituted amine phosphate component: Rat LD ₅₀ = 3,161 mg/kg b.w. (male), 3,828 mg/kg (females) (Measured for the free base)	Confidential study	Adequate.
		Substituted amine phosphate component: Mouse LD ₅₀ = 3,296 mg/kg (male), 7,014 mg/kg (female) (Measured for the free base)	Confidential study	Adequate.
		Substituted amine phosphate component: Mouse LD ₅₀ = 4,550 mg/kg (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Substituted amine phosphate component: Rat LD ₅₀ = 3,160 mg/kg (male) and 3850 mg/kg (female) (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: Rat LD ₅₀ >6,400 mg/kg (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Substituted amine phosphate component: LD ₅₀ ≈ 4,800 mg/kg	Confidential study	Limited study details reported in a confidential study.
		Piperazine: Rat LD ₅₀ = 1,900–4,500 mg/kg	IUCLID, 2000	Reported results taken from 3 studies. Limited study details reported in a secondary source.
		Piperazine: Mouse LD ₅₀ = 600–4,200 mg/kg	IUCLID, 2000	Reported results taken from 3 studies. Limited study details reported in a secondary source.
		Piperazine: Rat LD ₅₀ = 2,500 mg/kg	ECHA, 2011	Study details reported in a secondary source; according to Organisation of Economic Cooperation and Development (OECD) Guideline 401.
		Piperazine: Rat LD ₅₀ = 3,200 mg/kg	ECHA, 2011	Study details reported in a secondary source; according to OECD Guideline 401.
		Piperazine: Rat LD ₅₀ = 2,600 mg/kg	ECHA, 2011	Study details reported in a secondary source; according to OECD Guideline 401.
	Dermal	Piperazine: Rabbit LD ₅₀ = 4,000 mg/L	ECHA, 2011	Limited study details provided in a secondary source.
		Substituted amine phosphate component: Rabbit LD ₅₀ >1,000 mg/L	Confidential study	Limited study details reported in a confidential study.
	Inhalation	Substituted amine phosphate component: Rat LC ₅₀ = 3.248 mg/L	Confidential study	Study details, if present, were not translated into English; reported in a confidential study.
		Piperazine: Rat 4-hour LC ₅₀ = 2.0 mg/L	ECHA, 2011	Study details reported in a secondary source.
		Piperazine: Rat 4-hour LC ₅₀ = 0.8 mg/L	ECHA, 2011	Study details reported in a secondary source.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Piperazine: Rat 2-hour LC ₅₀ = 5.4 mg/L.	IUCLID, 2000	Limited study details reported in a secondary source.
Carcinogenicity		MODERATE: The carcinogenicity hazard potential for the substituted amine phosphate mixture is estimated to be Moderate based on the substituted amine phosphate component. There is evidence that oral exposure to the substituted amine phosphate component causes carcinogenicity in experimental animals. However, there is no evidence located as to the substituted amine phosphate component's carcinogenicity to humans. Tumor formation in animals appeared to happen in a mechanical nature under conditions in which it produced bladder calculi. No data were located as to the carcinogenic potential of the substituted amine phosphate mixture or salts. The International Agency for Research on Cancer (IARC) classifies the substituted amine phosphate component as Group 3: not classifiable as to its carcinogenicity to humans.		
	OncoLogic Results	Substituted amine phosphate component: Marginal (Estimated for free base)	OncoLogic, 2008	
	Carcinogenicity (Rat and Mouse)	Substituted amine phosphate component: Group 3: <i>It is not classifiable as to its carcinogenicity to humans</i> ; there is inadequate evidence in humans for carcinogenicity, and there is sufficient evidence in experimental animals for carcinogenicity under conditions in which it produces bladder calculi. (Measured for the free base)	IARC	Classification statement.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: Significant formation of transitional cell carcinomas in the urinary bladder of male rats and significant chronic inflammation in the kidney of dosed female rats were observed following exposure in the feed for up to 103 weeks. Carcinoma formation was significantly correlated with the incidence of bladder stones. A transitional-cell papilloma was observed in the urinary bladder of a single high dose male rat, and compound related lesions were observed in the urinary tract of dosed animals. (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: Increased incidence of acute and chronic inflammation and epithelial hyperplasia of the urinary bladder were observed in male mice following oral (feed) exposure for up to 103 weeks. Bladder stones and compound related lesions were observed in the urinary tract of test animals. There was no evidence of bladder tumor development. The compound was not considered carcinogenic. (Measured for the free base)	Confidential study	Reported in a confidential study.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: Proliferative lesions of the rat urinary tract were directly due to the irritant stimulation of calculi, and not to molecular interactions between it or its metabolites with the bladder epithelium. (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: Water intake, used as an index of urinary output, was increased by NaCl treatment. Calculus formation resulting from administration was suppressed dose-dependently by the simultaneous NaCl treatment. The main constituents of calculi were the substituted amine phosphate component and uric acid (total contents 61.1–81.2%). The results indicated proliferative lesions of the urinary tract of rats were directly due to the irritation-induced stimulation of calculi, and not molecular interactions between itself or its metabolites with the bladder epithelium. (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: As an initiator, it caused no significant increase in papillomas per mouse when compared to controls.	Confidential study	Reported in a confidential study; nonguideline study.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: Diffuse papillary hyperplasia of the bladder epithelium and bladder calculi were observed in all the treated rats. Elevated spermidine/spermine N1-acetyltransferase activity following treatment was considered to be an indicator of cell proliferation. (Measured for the free base)	Confidential study	Reported in a confidential study; nonguideline study.
		Substituted amine phosphate component: Decreased antitumor activity was correlated with increasing demethylation; the component was considered inactive as an antitumor drug. (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Substituted amine phosphate component: In an <i>in vitro</i> cytotoxicity study in cultured ADJ/PC6 plasmacytoma ascites tumor cells, the ID ₅₀ was 470 µg/mL after 72 hours of treatment. (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
	Combined Chronic Toxicity/ Carcinogenicity	Substituted amine phosphate component: No effects were observed in rats fed 1,000 ppm. 4 of the 10 rats fed 10,000 ppm had bladder stones associated with the development of benign papillomata. (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: Increased incidence of urinary bladder stones (6/20 rats) was noted in the 10,000 ppm dose group, and was associated with an increase in benign papillomata. The NOAEL was determined to be 1,000 ppm (67 mg/kg). (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
Genotoxicity		MODERATE: Estimated based on positive results for chromosomal aberrations <i>in vivo</i> in mice exposed to the substituted amine phosphate component and positive results for gene mutations following <i>in vitro</i> exposure to the piperazine component in mouse lymphoma assays. There were also positive results <i>in vitro</i> for DNA synthesis-inhibition in Hela S3 cell and genetic toxicity in <i>Escherichia coli</i> WP2s in a microscreen assay following exposure to the substituted amine phosphate component. No data were located for the substituted amine phosphate mixture salts regarding the genotoxicity endpoint.		
	Gene Mutation <i>in vitro</i>	Substituted amine phosphate component: Bacterial forward mutation assay: Negative with and without liver activation (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: Bacterial forward mutation assay: Negative (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Substituted amine phosphate component: Bacterial reverse mutation assay: Negative with and without liver activation (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Substituted amine phosphate component: Bacterial reverse mutation assay: Negative with and without unspecified metabolic activation (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: <i>In vitro</i> mouse lymphoma test: Negative with and without liver activation (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: Chinese hamster ovary (CHO) cells/hypoxanthine-guanine phosphoribosyl-transferase forward mutation assay: Negative with and without liver activation (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Piperazine: <i>S. typhimurium</i> TA98, TA100, TA1535, TA1537 gene mutation assay: Negative with and without metabolic activation (Measured for the free base)	IUCLID, 2000; ECHA, 2011	Study details reported in a secondary source; according to OECD Guideline 471.
		Piperazine: <i>E. coli</i> reverse mutation assay: Negative without metabolic activation	IUCLID, 2000	Results taken from several studies. Limited study details reported in a secondary source.
		Piperazine: Mouse lymphoma assay: Positive	IUCLID, 2000	Limited study details reported in a secondary source.
		Piperazine: Mammalian cell gene mutation assay; mouse lymphoma L5178Y cells; toxicity-related increases in gene mutations in the presence of metabolic activation and negative without metabolic activation	ECHA, 2011	Study details reported in secondary source; equivalent to OECD Guideline 476; test substance identified as piperazine polyphosphate.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Gene Mutation <i>in vivo</i>	Substituted amine phosphate component: <i>In vivo</i> mouse micronucleus test: The initial test gave a positive trend (P=0.003) for chromosomal damage; however, both peripheral blood smears and the repeat bone marrow test were negative. The overall conclusion was that the substituted amine phosphate component does not induce chromosomal damage. (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: <i>In vivo</i> mouse micronucleus test: Negative without activation (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Piperazine: <i>E. coli</i> reverse mutation assay: Negative without metabolic activation	IUCLID, 2000	Results taken from several studies. Limited study details reported in a secondary source.
	Chromosomal Aberrations <i>in vitro</i>	Substituted amine phosphate component: <i>In vitro</i> chromosomal aberrations test: Negative CHO cells with and without liver activation (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: <i>In vitro</i> sister chromatid exchange assay: Negative in CHO cells with and without liver activation (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: <i>In vitro</i> sister chromatid exchange assay: Negative in CHO cells with and without liver activation (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Piperazine: Chromosomal aberration assay: Negative in CHO cells with and without metabolic activation	ECHA, 2011	Study details reported in secondary source; equivalent to OECD Guideline 473.
	Chromosomal Aberrations <i>in vivo</i>	Substituted amine phosphate component: <i>In vivo</i> chromosome aberrations test in mice: Positive (Measured for the free base)	Confidential study	Reported in a confidential study.
	DNA Damage and Repair	Substituted amine phosphate component: <i>In vivo</i> and <i>in vitro</i> unscheduled DNA synthesis (UDS) test: None of the tested chemicals, including the substituted amine phosphate component were genotoxic hepatocarcinogens in the <i>in vivo</i> assay. They were also negative for UDS in the <i>in vitro</i> assay. (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Substituted amine phosphate component: SOS/ <i>umu</i> test: Negative for its ability to result in DNA damage and induce the expression of the <i>umu</i> operon	Confidential study	Reported in a confidential study; nonguideline study.
		Substituted amine phosphate component: DNA synthesis-inhibition test in Hela S3 cells: Inhibits DNA synthesis by 50% at greater than 300 µM (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Other	Substituted amine phosphate component: Sex-linked recessive lethal/reciprocal translocation: Results were considered equivocal based on 0.18% and 0.36% total lethality following oral and injection exposure, respectively, compared to control total lethal of 0.07% for oral and 0.09% for injection (Measured for the free base)	Confidential study	Reported in a confidential study.
		Substituted amine phosphate component: <i>Drosophila</i> Muller-5 test: Negative for mutagenicity (Measured for the free base)	Confidential study	Insufficient study details were reported in a confidential study.
		Substituted amine phosphate component: <i>Drosophila melanogaster</i> Sex-linked recessive lethal: No mutagenic effects were observed (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Substituted amine phosphate component: <i>In vitro</i> flow cytometric DNA repair assay: Negative for genotoxic effects (Measured for the free base)	Confidential study	Reported in a confidential study; nonguideline study.
		Substituted amine phosphate component: Microscreen assay: Positive for genetic toxicity in <i>E.coli</i> WP2 cells	Confidential study	Reported in a confidential study; nonguideline study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: Growth and genotoxic effects to bacteria (<i>Salmonella typhimurium</i>) and yeast (<i>Saccharomyces cerevisiae</i>): Non-mutagenic in <i>S.typhimurium</i> with or without S-9 mix. The growth of eight out of nine strains tested was delayed by 10 mM during 24 hr cultivation. <i>S. cerevisiae</i> strain was tested, and did not recover its growth following 48 hour cultivation. (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.
		Piperazine: Mammalian cell transformation test: Negative in mouse BALB/3T3 cells; piperazine did not induce transformed foci	ECHA, 2011	Study details reported in secondary source; according to EU method B.21.
Reproductive Effects		MODERATE: Hazard potential for reproductive toxicity of the substituted amine phosphate mixture is estimated to be Moderate based on data for the piperazine moiety from piperazine dihydrochloride; rats exposed to 300 mg/kg/day had decreased litter size in both generations. The NOAEL is identified at 125 mg/kg/day; there is uncertainly if effects could occur at doses between 125 and 250 mg/kg/day (the criteria cutoff dose for a Low hazard designation is >250 mg/kg/day). There were no adequate reproductive toxicity data located for the substituted amine phosphate mixture or substituted amine phosphate component of the mixture.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Reproduction and Fertility Effects	Piperazine: Rat, oral, 2-generation reproduction toxicity study; at 300 mg/kg/day: Decreased body weight gain in F ₀ males and in both sexes of F ₁ parental generation; no effect on number of pregnancies; decreased litter size in both generations (91% - F ₀ , 85% - F ₁ offspring); reduction of implantation sites in F ₁ females; no difference in offspring sex ratios. NOAEL = 227 mg/kg/day piperazine dihydrochloride (~125 mg/kg/day piperazine base) LOAEL = 544 mg/kg/day piperazine dihydrochloride (~300 mg/kg/day piperazine base)	ECHA, 2011	Reported in a secondary source. Test substance identified as piperazine dihydrochloride.
		Piperazine: Rat, oral; potential for reproductive toxicity NOAEL = 250 mg/kg/day	Professional judgment; Confidential study	Test substance is identified as piperazine dihydrochloride; a LOAEL was not identified. Reported in a confidential study.
		Substituted amine phosphate component: There were no treatment-related macroscopic or microscopic effects on mammary glands, ovaries, prostate, seminal vesicles, testes and uterus in rats and mice in a 13-week study. (Measured for the free base)	Confidential study	Limited study details reported in a confidential study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Developmental Effects		MODERATE: Hazard potential for developmental toxicity of the substituted amine phosphate mixture is estimated to be Moderate based on data for piperazine moiety from piperazine phosphate and professional judgment. There is uncertainty if effects could occur at doses between 94 and 250 mg/kg/day because a LOAEL was not identified (the criteria cutoff dose for a Low hazard designation is >250 mg/kg/day). Embryotoxicity was reported in conjunction with maternal toxicity and was considered to be a secondary effect. Data for the substituted amine phosphate component showed no developmental effects in rats exposed during gestation to doses up to 1,060 mg/kg-day. A conservative approach was used since there were no measured values for the substituted amine phosphate mixture.		
	Reproduction/ Developmental Toxicity Screen	Piperazine: Rabbit, oral; potential for developmental toxicity NOEL = 225 mg/kg/day	Professional judgment; Confidential study	Test substance identified as piperazine phosphate; a LOAEL was not identified. Reported in a confidential study.
		Piperazine: Rat, oral; potential for developmental toxicity NOEL = 1,000 mg/kg/day	Professional judgment; Confidential study	Test substance identified as piperazine phosphate; a LOAEL was not identified. Reported in a confidential study.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development	Substituted amine phosphate component: Signs of maternal toxicity at 136 mg/kg/day included decreased body weight and feed consumption, hematuria (23/25 rats), indrawn flanks (7/25 rats), and piloerection (1/25 rats). No adverse effects on gestational parameters and no signs of developmental toxicity were noted. NOAEL ≥1,060 mg/kg/day (Measured for the free base)	Confidential study	Reported in a confidential study.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Piperazine: Rabbit, oral, gestation days (GDs) 6-18. At 210 mg/kg/day piperazine base: maternal neurotoxicity, decreased body weight and food consumption; embryotoxic effects as resorption, retardation of ossification, and reduced fetal weight. These effects were considered secondary to maternal toxicity; no developmental effects or significant maternal toxicity was reported in the 94 mg/kg/day dose group. NOAEL (maternal toxicity) = 42 mg/kg/day piperazine base LOAEL (maternal toxicity) = 94 mg/kg/day piperazine base NOAEL (developmental) = 94 mg/kg/day piperazine base	ECHA, 2011	Reported in a secondary source. Test substance identified as piperazine phosphate; Developmental effects occurred at 210 mg/kg/day piperazine base; however, these effects occurred in conjunction with maternal toxicity and are considered secondary effects.
		Piperazine: Rat, oral, GD 6-15. At 210 mg/kg/day piperazine base: maternal toxicity: excessive salivation, lethargy and reduced body weight gain, body weight and food consumption at 2,100 mg/kg/day; No embryotoxic effects reported. NOAEL (maternal toxicity) = 420 mg/kg/day piperazine base LOAEL (maternal toxicity) = 2,100 mg/kg/day piperazine base NOAEL (developmental) = 2,100 mg/kg/day piperazine base	ECHA, 2011	Reported in a secondary source. Test substance identified as piperazine phosphate.
		Piperazine: Rabbit, oral; potential for developmental effects NOAEL = 225 mg/kg/day	Professional judgment	Estimated based on professional judgment.
	Postnatal Development			No data located.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Neurotoxicity		LOW: Neurotoxicity hazard potential of the substituted amine phosphate mixture is estimated to be low based on expert judgment.		
	Neurotoxicity Screening Battery (Adult)	Potential for neurotoxicity is expected to be low. (Estimated)	Expert judgment	Estimated based on expert judgment.

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects	MODERATE: Repeated dose effects from the substituted amine phosphate mixture is estimated based on effects following repeated oral exposure to the substituted amine phosphate component in rats. Decreased body weight gain and feed consumption along with stones and diffuse epithelial hyperplasia in the urinary bladder were reported at a dose of 72 mg/kg/day. No data were located for the substituted amine phosphate mixture or salts.		
	Substituted amine phosphate component: Rat 28-day dietary toxicity study: Clinical signs included a dose-related increase in piloerection, lethargy, bloody urine spots in the cage and on the pelage of animals, and chromodacryorrhea. The incidence of urinary bladder calculi and urinary bladder hyperplasia in treated animals was dose-dependent, with a significant relationship between the calculi and hyperplasia. Calculi composition indicated the presence of an organic matrix containing the substituted amine phosphate component, phosphorus, sulfur, potassium, and chloride. Crystals of its monophosphate were identified in the urine. NOAEL: 2,000 ppm (240 mg/kg/day), excluding the observed increase in water consumption and the incidence of crystalluria LOAEL: 4,000 ppm (475 mg/kg/day) based on the formation of calculus (Measured for the free base)	Confidential study	Reported in a confidential study.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Substituted amine phosphate component: Rabbit and dog 28-day dietary toxicity study: No significant rise in the body temperature of rabbits was noted. Gross histological examination of the heart, lung, liver, spleen, thyroid, pancreas, intestines, kidneys and bladder did not show pathological changes. A zone of fat was found in the inner part of the renal cortex in 2 dogs, but also in the kidneys of 3 control dogs. (Measured for the free base)	Confidential study	Insufficient study details were reported in a confidential study. Unspecified number of animals tested.
	Substituted amine phosphate component: Rat 28-day dietary toxicity study: Incidence and size of bladder stones were directly related to the amount of substance administered. The larger stones were found to be unchanged in a matrix of protein, uric acid and phosphate. Lowest effective dose (LED): 1,500 ppm (~125 mg/kg) in males (Measured for the free base)	Confidential study	Insufficient study details were reported in a confidential study.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Substituted amine phosphate component: Rat 90-day dietary toxicity study: 1 male rat administered 18,000 ppm and 2 males administered 6,000 ppm died. Mean body weight gain and feed consumption were reduced. Stones and diffuse epithelial hyperplasia in the urinary bladders were observed in male rats of all treatment groups. Focal epithelial hyperplasia was observed in only 1 male. A second and third 13-week repeated dose toxicity study was conducted in rats at a dose range of 750 to 18,000 ppm bladder stones were observed at all dose levels. LOAEL: 750 ppm (72 mg/kg-day) based on urinary bladder stones (Measured for the free base)	Confidential study	Reported in a confidential study.

Substituted Amine Phosphate Mixture

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Substituted amine phosphate component: Mouse 90-day dietary toxicity study: A single female mouse died after receiving 9,000 ppm. Mean body weight gain relative to controls was depressed. The incidence of mice with bladder stones was dose-related and was greater in males than in females. 60% of mice having bladder ulcers also had urinary bladder stones. Bladder ulcers were multifocal or associated with inflammation (cystitis). Epithelial hyperplasia and bladder stones were observed together in 2 mice. Also, epithelial cell atypia was seen. NOAEL: 6,000 ppm (600 mg/kg-day) LOAEL: 9,000 ppm (900 mg/kg-day) (Measured for the free base)	Confidential study	Reported in a confidential study.
	Substituted amine phosphate component: Increased incidence of acute and chronic inflammation and epithelial hyperplasia of the urinary bladder was observed in mice following oral (feed) exposure for up to 103 weeks. There was also increased incidence of bladder stones in male mice. LOAEL = 2,250 mg/kg diet (lowest dose tested) (Measured for the free base)	Confidential study	Reported in a confidential study. Repeated dose effects described in a carcinogenicity bioassay study.
	Substituted amine phosphate component: Dog 1-Year dietary toxicity study: Crystalluria started 60 to 90 days into treatment and persisted during the study period. No other effects were observed.	Confidential study	Insufficient study details were reported in a confidential study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate component: Rat 30-month dietary toxicity study: Neither accumulation of calculi nor any treatment-related urinary bladder lesions were found. (Measured for the free base)	Confidential study	Insufficient study details were reported in a confidential study.
		Substituted amine phosphate component: Rat 24 to 30-month dietary toxicity study: A dose-related trend for dilated glands in glandular gastric mucosa and inflammation in nonglandular gastric mucosa was observed. Urinary bladder calculi formation was not observed. (Measured for the free base)	Confidential study	Insufficient study details were reported in a confidential study.
		Piperazine: Rat 90-day dietary toxicity study: Only effect noted was a treatment-related decrease in body weight gain (>10%) NOAEL: 627 mg/kg-day LOAEL = 2,394 mg/kg-day	ECHA, 2011	According to guideline: FDA 1986, Toxicological principles for Safety Assessment of Direct Food Additives and Color Additives Used in Food; sufficient study details reported in a secondary source; dose recalculated to piperazine base.
	Immune System Effects	Potential for immunotoxicity is expected to be low. (Estimated)	Expert judgment	Estimated based on expert judgment.
		Substituted amine phosphate component: No inhibition of <i>in vitro</i> murine lymphocyte mitogenesis. (Measured for the free base)	Confidential study	Reported in a confidential study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Skin Sensitization		LOW: Neither the substituted amine phosphate mixture nor the piperazine pyrophosphate component are skin sensitizers.		
	Skin Sensitization	Substituted amine phosphate mixture: No skin sensitization in guinea pigs using Magnusson-Kligman assay (Estimated by analogy)	Professional judgment; Confidential study	Based on closely related analogs with similar structures, functional groups, and physical/chemical properties.
		Substituted amine phosphate mixture: Not a skin sensitizer based on local lymph node assay (LLNA) in the mouse.	Submitted confidential study	Study details reported in a confidential study; conducted according to OECD 429;
		Piperazine pyrophosphate: No skin sensitization in guinea pigs using Magnusson-Kligman assay	Submitted confidential study	Study details reported in a confidential study; test substance purity >95%; study conducted according to OECD 406
Respiratory Sensitization		MODERATE: Respiratory sensitization hazard potential for the substituted amine phosphate mixture is estimated to be Moderate based on analogy to the piperazine-containing compounds.		
	Respiratory Sensitization	Piperazine moiety: Hazard potential for respiratory sensitization. (Estimated by analogy)	Professional judgment	Estimated based on analogy to piperazine-containing compounds.
Eye Irritation		MODERATE: Based on indications of mild to moderate eye irritation in rabbits for both the substituted amine phosphate and piperazine pyrophosphate components of the substituted amine phosphate mixture. In addition, eye irritation hazard due to the substituted amine phosphate mixture is estimated to be Moderate based on data for a confidential analog showing eye irritation in rabbits.		
	Eye Irritation	Substituted amine phosphate mixture: Moderate eye irritation in rabbits. (Estimated by analogy)	Professional judgment; Confidential studies	Reported in a confidential study. Based on two closely related analogs with similar structures, functional groups, and physical/chemical properties.
		Substituted amine phosphate component: Mildly irritating to rabbit eyes.	Submitted confidential study	Limited study details reported in a confidential study.
		Piperazine pyrophosphate: Moderately irritating to rabbit eyes.	Submitted confidential study	Study details reported in a submitted confidential study.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Dermal Irritation		VERY LOW: Based on no indication of dermal irritation for the substituted amine phosphate component and no irritation to mild irritation for the piperazine pyrophosphate component of the substituted amine phosphate mixture.		
	Dermal Irritation	Substituted amine phosphate mixture: Not irritating to rabbit skin. (Estimated by analogy)	Professional judgment; Submitted confidential study	Reported in a confidential study. Based on closely related analogs with similar structures, functional groups, and physical/chemical properties.
		Substituted amine phosphate component: Not irritating to rabbit skin.	Submitted confidential study	Study details reported in a confidential study.
		Piperazine pyrophosphate: Not irritating to mild irritation to rabbit skin.	Submitted confidential study	Study details reported in a submitted confidential study.
Endocrine Activity		There were insufficient data located to describe the effect of the substituted amine phosphate mixture on the endocrine system. In one study, the substituted amine phosphate component did not exhibit estrogenic activity <i>in vitro</i> in a yeast two-hybrid assay.		
		Substituted amine phosphate component: Showed no estrogenic activity (no change in B-galactosidase activity) in an <i>in vitro</i> yeast two-hybrid assay in <i>Saccharomyces cerevisiae</i> Y 190. (Measured for the free base)	Confidential study	Reported in a confidential study. No guideline followed.
Immunotoxicity		There is estimated to be no potential for immunotoxicity of the substituted amine phosphate mixture based on expert judgment. Data located for the substituted amine phosphate component are not sufficient to determine the hazard potential for this endpoint.		
	Immune System Effects	Potential for immunotoxicity is expected to be low. (Estimated)	Expert judgment	Estimated based on expert judgment.
		Substituted amine phosphate component: No inhibition of <i>in vitro</i> murine lymphocyte mitogenesis. (Measured for the free base)	Confidential study	Reported in a confidential study.

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
ECOTOXICITY			
ECOSAR Class	Substituted amine phosphate component: Confidential structure class; Piperazine pyrophosphate: Aliphatic amines.		
Acute Toxicity	MODERATE: Acute toxicity hazard for the substituted amine phosphate mixture is estimated based on an experimental LC₅₀ value of 21 mg/L in <i>Daphnia magna</i> for the piperazine moiety of the ionized mixture which represents the most conservative value. Although measured toxicity values for the substituted amine phosphate free base indicate a low hazard designation for this component of the mixture, a conservative approach was used since there are no measured values for the substituted amine phosphate mixture.		
Fish LC₅₀	Substituted amine phosphate component: <i>Leuciscus idus melanotus</i> 48-hour LC ₅₀ >500 mg/L (Experimental)	Confidential study	Study details reported in a confidential study.
	Substituted amine phosphate component: <i>Oryzias latipes</i> 48-hour LC ₅₀ = 1,000 mg/L (Experimental)	Confidential study	Study details reported in a confidential study.
	Substituted amine phosphate component: <i>Poecilia reticulata</i> 96-hour LC ₅₀ >3,000 mg/L (Experimental)	Confidential study	Study details reported in secondary source.
	Substituted amine phosphate component: <i>Poecilia reticulata</i> 4,400 mg/L dose lethal to <10% (Experimental)	Confidential study	Study details reported in a confidential study; unspecified exposure duration.
	Piperazine: <i>Poecilia reticulata</i> (guppy) 96-hour LC ₅₀ >1,800 mg/L Semi-static conditions (Experimental)	ECHA, 2011	Study details reported in a secondary source; according to EU Method C.1.
	Substituted amine phosphate component: Fish 96-hour LC ₅₀ = 391 mg/L (Estimated) ECOSAR: Confidential structure class	ECOSAR version 1.11	

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Substituted amine phosphate component: Fish 96-hour LC ₅₀ = 14,272 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Piperazine pyrophosphate: Fish 96-hour LC ₅₀ >10,000 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	No effects at saturation (NES): The LC ₅₀ value exceeds the water solubility (1.0e ⁺⁶ mg/L); NES are predicted for these endpoints.
	Piperazine pyrophosphate: Fish 96-hour LC ₅₀ ≥10,000 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The LC ₅₀ value exceeds the water solubility (1.0e ⁺⁶ mg/L); NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid LC₅₀	Substituted amine phosphate component: <i>Daphnia magna</i> 48-hour LC ₅₀ >2,000 mg/L (Experimental)	Confidential study	Study details reported in a confidential study.
	Piperazine: <i>Daphnia magna</i> 48-hour LC ₅₀ = 21 mg/L Static conditions (EU Method C.2) (Experimental)	ECHA, 2011	Study details reported in a secondary source; guideline study.

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Substituted amine phosphate component: Daphnid 48-hour LC ₅₀ = 144 mg/L (Estimated) ECOSAR: Confidential structure class	ECOSAR version 1.11	
	Substituted amine phosphate component: Daphnid 48-hour LC ₅₀ = 4,805 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Piperazine pyrophosphate: Daphnid 48-hour LC ₅₀ >10,000 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	
	Piperazine pyrophosphate: Daphnid 48-hour LC ₅₀ >10,000 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The LC ₅₀ value exceeds the water solubility (1.0x10 ⁶ mg/L); NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Substituted amine phosphate component: <i>Scenedesmus pannonicus</i> 4-day EC ₅₀ = 940 mg/L (Experimental); 4-day NOEC = 320 mg/L (Experimental)	Confidential study	Reported in a confidential study.; Study details and test conditions were not provided.

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Substituted amine phosphate component: Green algae 96-hour EC ₅₀ = 325 mg/L (Estimated) ECOSAR: Confidential structure class	ECOSAR version 1.11	
	Substituted amine phosphate component: Green algae 96-hour EC ₅₀ = 4,396 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Piperazine pyrophosphate: Green algae 96-hour EC ₅₀ >10,000 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	
	Piperazine pyrophosphate: Green algae 96-hour EC ₅₀ >10,000 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The LC ₅₀ value exceeds the water solubility (1.0x10 ⁶ mg/L); NES are predicted for these endpoints.
Chronic Aquatic Toxicity	LOW: The substituted amine phosphate mixture chronic toxicity hazard potential is estimated based on measured chronic toxicity values for the piperazine moiety, on estimated values for piperazine pyrophosphate, and on estimated values for the substituted amine phosphate component of the mixture, for all three surrogate species.		
Fish ChV	Substituted amine phosphate component: <i>Jordanella floridae</i> 35-day NOEC ≥1,000 mg/L (Experimental)	Confidential study	Reported in a confidential study; study details and test conditions were not provided.
	Substituted amine phosphate component: <i>Salmo gairdneri</i> NOEC (macroscopic) = 500 mg/L (Experimental); NOEC (microscopic) <125 mg/L (Experimental)	Confidential study	Reported in a confidential study; study details and test conditions were not provided.

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Substituted amine phosphate component: <i>Daphnia magna</i> 21-day LC ₅₀ = 32-56 mg/L, 21-day LC ₁₀₀ = 56 mg/L, 21day NOEC = 18 mg/L (Experimental)	Confidential study	Reported in a confidential study; study details and test conditions were not provided.
	Substituted amine phosphate component: Fish ChV = 1,102 mg/L (Estimated) ECOSAR: Confidential structure class	ECOSAR version 1.11	
	Substituted amine phosphate component: Fish ChV = 1,076 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Piperazine pyrophosphate: Fish ChV ≥10,000 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	
	Piperazine pyrophosphate: Fish ChV ≥10,000 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The LC ₅₀ value exceeds the water solubility (1.0x10 ⁶ mg/L); NES are predicted for these endpoints. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Daphnid ChV	Piperazine: <i>Daphnia magna</i> 21-day NOEC = 12.5 mg/L (immobile neonates) LOEC = 25 mg/L (immobile neonates) NOEC = 50 mg/L (reproduction) NOEC = 25 mg/L (growth) Semi-static conditions (OECD Guideline 211) (Experimental)	ECHA, 2011	Study details reported in a secondary source; guideline study.
	Substituted amine phosphate component: Daphnid ChV = 14.85 mg/L (Estimated) ECOSAR: Confidential structure class	ECOSAR version 1.11	The toxicity value was estimated through application of acute to chronic ratios (ACRs).
	Substituted amine phosphate component: Daphnid ChV = 343.93 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Piperazine pyrophosphate: Daphnid ChV = 2,408 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	
	Piperazine pyrophosphate: Daphnid ChV >10,000 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The LC ₅₀ value exceeds the water solubility (1.0x10 ⁶ mg/L); NES are predicted for these endpoints.

Substituted Amine Phosphate Mixture			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Green Algae ChV	Piperazine: <i>Selenastrum capricornutum</i> (<i>Pseudokirchnerella subcapitata</i>) 72-hour NOEC >1,000 mg/L (growth rate) Static conditions (OECD Guideline 201) (Experimental)	ECHA, 2011	Study details reported in secondary source; guideline study.
	Substituted amine phosphate component: Green algae ChV = 0.70 mg/L (Estimated) ECOSAR: Confidential structure class	ECOSAR version 1.11	The toxicity value was estimated through application of ACRs.
	Substituted amine phosphate component: Green algae ChV = 81.26 mg/L (Estimated) ECOSAR: Confidential structure class	ECOSAR version 1.11	The toxicity value was estimated through application of ACRs.
	Substituted amine phosphate component: Green algae ChV = 313.17 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	
	Piperazine pyrophosphate: Green algae ChV >10,000 mg/L (Estimated) ECOSAR: Aliphatic amines	ECOSAR version 1.11	
	Piperazine pyrophosphate: Green algae ChV = 259,000 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		The substituted amine phosphate mixture is comprised of approximately 50% piperazine pyrophosphate and 50% of a substituted amine phosphate. Both of these ionic compounds have high estimated water solubility. Therefore, this mixture can be expected to partition predominately to water and soil. The components are anticipated to migrate from soil into groundwater based on the estimated K_{oc} values of <100. Volatilization from either wet or dry surfaces is not expected to be an important fate process based on the estimated vapor pressure of this mixture.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment	In water, the substituted amine phosphate mixture components are expected to be fully dissociated. Volatilization of the dissociated species from either wet surfaces is not expected to be an important fate process.
		Piperazine pyrophosphate: <10 ⁻¹⁰ (Estimated)	EPI	
		Substituted amine phosphate: <10 ⁻¹⁰ (Estimated)	EPI	
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	Piperazine pyrophosphate: 62 (Estimated)	EPI	
		Substituted amine phosphate: 13 (Estimated)	EPI	
	Level III Fugacity Model	Piperazine pyrophosphate: Air: <1% (Estimated) Water = 20% Soil = 80% Sediment: <1%	EPI	

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate: Air: <1% (Estimated) Water = 35% Soil = 65% Sediment: <1%	EPI	
Persistence		HIGH: The substituted amine phosphate mixture is estimated to show high persistence in the environment based on experimental data for the organic components. The persistence of the inorganic phosphate components of this mixture were not considered to be a factor in the assignment of this hazard designation. The organic component of the confidential substituted amine phosphate undergoes biodegradation according to measured results; however the rates of removal are slow. The organic portion of the substituted amine phosphate component is considered to be inherently biodegradable, not readily biodegradable.		
Water	Aerobic Biodegradation	Piperazine pyrophosphate: Days-Weeks (Primary survey model) Weeks-Months (Ultimate survey model) (Estimated)	EPI	
		Piperazine: Not readily biodegradable according to OECD 301C; 1.4% degradation after 2 weeks. (Measured for free base)	MITI, 1998	Measured biodegradation indicate slow removal by this pathway for the dissociated species, piperazine.
		Piperazine: Readily biodegradable according to OECD 301F; 65-70% in 2 weeks by O ₂ and CO ₂ and 39% by dissolved organic carbon and OECD 301D; 90% in 2 weeks. Inherently biodegradable according to 302A; 96% degradation after 52 days. (Measured for free base)	ECHA, 2011	Measured biodegradation indicate potential for biodegradation for the dissociated species, piperazine.
		Substituted amine phosphate: Weeks (Primary survey model) Months (Ultimate survey model) (Estimated)	EPI	

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Substituted amine phosphate dissociation product: The range of reported aerobic biodegradation rates span from 0% removal to <30% removal after 14 days with activated sludge. (Measured for dissociation species)	Confidential study	Measured biodegradation indicate limited removal by this pathway for a dissociated species of the substituted amine phosphate.
	Volatilization Half-life for Model River	>1 year (Estimated)	Professional judgment	Based on the estimated Henry's Law Constant and the low rates of volatilization for completely dissociated species; applies to both ionic solids present in the substituted amine phosphate mixture.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	Professional judgment	Based on the estimated Henry's Law Constant and the low rates of volatilization for completely dissociated species; applies to both ionic solids present in the substituted amine phosphate mixture.
Soil	Aerobic Biodegradation	Substituted amine phosphate dissociation product: Not readily biodegradable: 0% biodegradation detected after 2 weeks with 100 ppm in 30 ppm activated sludge (OECD TG 301C) (Measured); 0% degradation after 28 days with 100 mg DOC/L in activated sludge (Zahn-Wellens test, OECD 302B). (Measured) Piperazine: In a variety of soil samples, complete degradation took 24 to 68 days with a lag period of 15 to 60 days respectively. Some samples reported no degradation at 3 months. (Measured for free base)	Confidential study; EU RAR, 2005	Value for dissociation product of the substituted amine phosphate component and piperazine pyrophosphate dissociation species, piperazine. Measured biodegradation demonstrate removal by this pathway.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Anaerobic Biodegradation	Substituted amine phosphate dissociation product: 0-8.9% nitrification was observed after 28 days incubation with bacteria in Webster silty clay loam under anaerobic conditions. (Measured) Piperazine: No degradation after 6 months under denitrifying, sulfate reducing, or methanogenic conditions. (Measured for free base)	Confidential study; Bae, 2002	Value for dissociated component of the substituted amine phosphate and piperazine pyrophosphate dissociation species, piperazine. Measured biodegradation rates demonstrate no removal by this pathway.
	Soil Biodegradation with Product Identification	Substituted amine phosphate dissociation product: Nitrification occurs in soil at a low rate (0.7 % organic N found as NO ₃ -N in week 10, and 0 % in week 28). (Measured)	Confidential study	Nonguideline study for the dissociated product of the substituted amine phosphate component.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life			No data located.
Reactivity	Photolysis	Substituted amine phosphate: Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	This compound does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths.
		Piperazine: 0.8 hour half-life (Measured for free base)	OECD SIDS, 2004	Value for piperazine pyrophosphate dissociation species, piperazine.
	Hydrolysis	Not a significant fate process (Estimated)	Wolfe and Jeffers, 2000; Professional judgment	Both ionic solids present in the substituted amine phosphate mixture do not contain functional groups that would be expected to hydrolyze readily under environmental conditions.

Substituted Amine Phosphate Mixture				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Environmental Half-Life		Substituted amine phosphate: 120 days (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.
		Piperazine pyrophosphate: 75 days (Estimated)	EPI; PBT Profiler	
Bioaccumulation		LOW: The substituted amine phosphate mixture is expected to have low potential for bioconcentration and bioaccumulation based on estimated BCF and BAF values of <100 for the two components of the mixture, piperazine pyrophosphate and substituted amine phosphate.		
	Fish BCF	Piperazine pyrophosphate: 3.2 (Estimated)	EPI	
		Substituted amine phosphate component: 3.2 (Estimated)	EPI	
	BAF	Piperazine pyrophosphate: 0.9 (Estimated)	EPI	
		Substituted amine phosphate component: 0.9 (Estimated)	EPI	
	Metabolism in Fish	Substituted amine phosphate dissociation product: Uptake, bioaccumulation and elimination study with ¹⁴ C-labeled compound in fathead minnow (BCF = 0.48 and 0.26) and rainbow trout (BCF = 0.11, 0.05, 0.03) (Measured)	Confidential study	Nonguideline study that supports the low bioaccumulation potential for this substance and its dissociation products.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		These chemicals were not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether

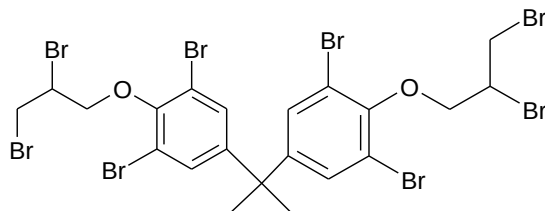
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether	21850-44-2	L	M	M	M	M	L	M	L		L	L	L	L	VH	H

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether



CASRN: 21850-44-2

MW: 943.62

MF: C₂₁H₂₀Br₈O₂

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: O(c1c(cc(cc1Br)C(c1cc(c(OCC(Br)CBr)c(c1)Br)Br)(C)C)Br)CC(Br)CBr

Synonyms: Benzene, 1,1'-(1-methylethylidene)bis[3,5-dibromo-4-(2,3-dibromopropoxy)-; 1,1'-(1-Methylethylidene)bis(3,5-dibromo-4-(2,3-dibromopropoxy))benzene; 1,1'-(1-Methylethylidene)bis[3,5-dibromo-4-(2,3-dibromopropoxy)]benzene; 1,1'-(Isopropylidene)bis(3,5-dibromo-4-(2,3-dibromopropoxy)benzene); 1,1'-(isopropylidene)bis[3,5-dibromo-4-(2,3-dibromopropoxy)benzene]; 1,1'-propane-2,2-diylbis[3,5-dibromo-4-(2,3-dibromopropoxy)benzene]; 2,2-Bis[3,5-dibromo-4(2,3-dibromopropoxy)phenyl]propane; 2,2-Bis[3,5-dibromo-4-(2,3-dibromopropoxy)phenyl]propane; 2,2-Bis[4-(2,3-dibromopropoxy)-3,5-dibromophenyl]propane; 3,3',5,5'-TetrabromobisphenolA bis(2,3-dibromopropyl) ether; 4,4'-Isopropylidenebis[2,6-dibromo-1-(2,3-dibromopropoxy)benzene]; 403AF; Bis(2,3-dibromopropoxy)tetrabromobisphenol A; Bromcal 66.8; Bromkal 66-8; D 5532; Dibromopropydian; FG 3100; FR 720; Fire guard 3100; Flame Cut 121K; Flame Cut 121R; GX 5532; Propane, 2,2-bis[3,5-dibromo-4-(2,3-dibromopropoxy)phenyl]-; PE-68; Pyroguard SR 720; SR 720; SAYTEX HP-800 A; HP-800 AG; HP-800 AGC; Tetrabromobisphenol A bis(2,3-dibromopropyl ether); Tetrabromobisphenol A bis(2,3-dibromopropyl) ether; Tetrabromobisphenol-A-bis-2,3-dibromopropyl ether Tetrabromobisphenol-A-bis-2,3-dibromopropylether; TBBPA-DBPE

Chemical Considerations: This is a discrete organic chemical with a MW below 1,000. EPI v 4.0 was used to estimate physical/chemical and environmental fate values as required. Measured values for available endpoints were incorporated into the estimations.

Polymeric: No

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: None identified; although this compound contains a TBBPA backbone, degradation of this compound to TBBPA has not been demonstrated in a published study. The hazards of the theoretical degradation products were not considered in this hazard assessment.

Analog: No analog

Endpoint(s) using analog values: Not applicable

Analog Structure: Not applicable

Structural Alerts: Polyhalogenated aromatic hydrocarbons, immunotoxicity (EPA, 2011).

Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community & IUCLID (Pakalin et al., 2007).

Hazard and Risk Assessments: Risk assessment complete for TBBPA bis (2,3-dibromopropyl) ether by the European Chemicals Bureau in 2007 (Pakalin et al., 2007).

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	117 (Measured)	Tokyo Chemical Industry Co., 2010; ChemSpider, 2011	Selected value for assessment.
	114 (Measured)	NICNAS, 2001	Sufficient details were not available to assess the quality of this study; value reported in a secondary source.
	90-100 (Measured)	IPCS, 1995; Great Lakes Chemical Corporation, 1982a	These reported values may be for a commercial mixture.
	95 (Measured)	Mack, 2004	
	107.3 (Measured) Reported as a range 104.3-116.6 using Optical melting determination	ECHA, 2013	Nonguideline, non-good laboratory practice (GLP) study reported in a secondary source.
	113.39 (Measured) Differential scanning calorimeter	ECHA, 2013	Nonguideline, non-GLP study reported in a secondary source.
Boiling Point (°C)	Decomposition at >270 (Measured)	IPCS, 1995	Decomposition is expected before the boiling point is reached.
Vapor Pressure (mm Hg)	2.2 ± 0.15 × 10 ⁻⁴ at 20°C Static test according to Organisation of Economic Cooperation and Development (OECD) TG 104 (Vapor pressure curve) and EU Method A.4 (Vapor Pressure); GLP study; Purity of test substance 95.1% (Measured)	ECHA, 2013	Guideline study reported for FR-720 in a secondary source.
	<10 ⁻⁸ (Estimated)	EPI; EPA, 1999	Cutoff value for nonvolatile compounds according to HPV assessment guidance.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Water Solubility (mg/L)	<10 ⁻³ (Estimated)	EPI; EPA, 1999	Cutoff value for non soluble compounds according to High Production Volume assessment guidance.
	1×10 ³ (Measured)	IPCS, 1995	Inadequate; these values are not consistent with a non polar, highly brominated material with a MW near 1,000.
	<1×10 ³ (Measured)	NICNAS, 2001	
	<0.1 mg/L (Measured) Reported as 0.144 µg/L at 20°C using OECD TG 105 (Water solubility) column elution method; GLP-study; Radiochemical purity of test substance (¹⁴ C-TBBPA-DBPE) > 99%.	ECHA, 2013	Cutoff value from a guideline study reported in a secondary source.
Log K_{ow}	12 (Estimated)	EPI; EPA, 1999	Estimated value is greater than the cutoff value, >10, according to methodology based on HPV assessment guidance.
Flammability (Flash Point)	Autoignition: 740°C (Measured) Ignition produced orange flame; according to IEC 61241-2-1 Method B Minimum ignition; GLP study	ECHA, 2013	Nonguideline study; purity of test substance TDBPE 720 not stated. Reported in a secondary source.
	Autoignition: >500 mJ (Measured) No ignition was observed; according to IEC 61241-2-3 Minimum ignition energy; GLP study	ECHA, 2013	Nonguideline; purity of test substance TDBPE 720 not stated. Reported in a secondary source.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pK _a		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
HUMAN HEALTH EFFECTS				
Toxicokinetics		TBBPA bis (2,3-dibromopropyl) ether, as a neat material, is estimated not to be absorbed through the skin, to have poor skin absorption when in solution, and to have poor absorption via the lungs and gastrointestinal tract. An experimental study in rats showed that the majority (95%) of TBBPA bis (2,3-dibromopropyl) ether is rapidly eliminated in the feces following single or multiple oral doses and absorption is slow and minimal. However, if absorbed, TBBPA bis (2,3-dibromopropyl) ether is slowly eliminated from the blood, with the liver being the main organ for deposition.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Not absorbed through the skin as a neat material and poor absorption through skin when in solution; poor absorption through the lung and gastrointestinal tract. (Estimated by analogy)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
		Following single or repeated (5 or 10 days) oral administrations of 20 mg/kg [¹⁴ C]-TBBPA bis (2,3-dibromopropyl) ether to male F-344 rats, the compound was poorly absorbed from the gastrointestinal tract and uptake to the systemic circulation was considered slow. The C _{max} (0.6 µg/mL) occurred at 7.4 hours after dosing. Distribution to the tissues accounted for <1% of the dose at 96 hours while 95% of the dose (in [¹⁴ C] equivalents) was excreted in the feces within 36 hours of administration. Elimination in the urine accounted for <0.1% of the administered dose and 1% of the dose (as metabolites) was excreted in the bile after 24 hours.	Knudsen et al., 2007; ECHA, 2013	Study details reported in primary source.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Other	Male Fischer-344 rats were dosed with TBBA-DBPE by IV administration. Fecal excretion of [¹⁴ C] equivalents was 27% by 36h, 71% by 96h. Urinary elimination was minimal (<0.1%). A single peak that co-eluted with the standard of TBBA-DBPE was detected in extracts of whole blood following IV administration. TBBA-DBPE elimination from the blood was slow. Kinetic constants following IV dosing were: t _{1/2b} : 24.8h; CL _b : 0.1mL/min. Systemic bioavailability was 2.2%. Liver was the major site of disposition.	ECHA, 2013	Well conducted study. Not performed according to GLP and standard testing guidelines.
Acute Mammalian Toxicity		LOW: Based on oral and dermal LD ₅₀ values >2, 000 mg/kg and an inhalation LC ₅₀ value >20 mg/L.		
Acute Lethality	Oral	Mouse LD ₅₀ >20,000 mg/kg	IPCS, 1995	Limited study details reported in a secondary source.
		Rat oral LD ₅₀ > 2,000 mg/kg	ECHA, 2013	Sufficient study details reported in a secondary source. GLP study conducted using OECD guidelines.
	Dermal	Mouse LD ₅₀ >20,000 mg/kg	IPCS, 1995	Limited study details reported in a secondary source.
		Rat dermal LD ₅₀ > 2,000 mg/kg	ECHA, 2013	Sufficient study details reported in a secondary source. GLP study conducted using OECD guidelines.
	Inhalation	Mouse LC ₅₀ >87,000 mg/m ³ (87 mg/L)	Great Lakes Chemical Corporation, 1982b	Limited study details reported in a secondary source.
		Rat 1 hr-inhalation LC ₅₀ >24.4 mg/L; Whole-body exposure to dust.	ECHA, 2013	Sufficient study details reported in a secondary source.
Carcinogenicity		MODERATE: No data located. Estimated to have potential for carcinogenicity based on the potential for alkylation and professional judgment.		
	OncoLogic Results			No data located.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Carcinogenicity (Rat and Mouse)	There is potential for carcinogenicity effects based on a mechanistic consideration of the potential for alkylation (Estimated)	Professional judgment	Based on mechanistic considerations.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		MODERATE: TBBPA bis (2,3-dibromopropyl) ether was mutagenic to <i>Salmonella typhimurium</i> in one assay, while it was negative in other assays in <i>S. Typhimurium</i> and <i>E. coli</i>. This substance was also negative for mutagenicity in mouse lymphoma cells. TBBPA bis (2,3-dibromopropyl) ether is also estimated to have potential for genotoxicity based on the potential for alkylation. TBBPA bis (2,3-dibromopropyl) ether did not cause chromosomal aberrations or sister chromatid exchanges in Chinese hamster ovary (CHO) cells (<i>in vitro</i>), was negative in an <i>in vivo</i> micronucleus assay in mice and did not produce unscheduled DNA synthesis in rats.		
	Gene Mutation <i>in vitro</i>	There is potential for mutagenicity based on a mechanistic consideration of the potential for alkylation. (Estimated)	Professional judgment	Based on closely related confidential analogs with similar structures and functional groups.
		Positive, Ames assay (standard plate) in <i>Salmonella typhimurium</i> strains TA1535 and TA100 with and without metabolic activation and TA98 without metabolic activation.	Great Lakes Chemical Corporation, 1982a; ECHA, 2013	Sufficient study details reported.
		Negative, <i>Salmonella typhimurium</i> strains TA1535, TA1537, TA100 and TA98 and <i>Escherichia coli</i> Wp2uvrA with and without metabolic activation.	Submitted confidential study; ECHA, 2013	Reported in a submitted confidential study; Study conducted according to GLP.
		Negative, mouse lymphoma L5178Y cells with and without metabolic activation.	Submitted confidential study; ECHA, 2013	Reported in a submitted confidential study; Study conducted according to GLP.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative chromosomal aberrations in CHO cytogenetic assay with and without metabolic activation (precipitation was observed at the highest concentration).	IPCS, 1995	Reported in a secondary source.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Negative, sister chromatid exchanges in CHO cells with and without metabolic activation.	Submitted confidential study	Reported in a submitted confidential study; Study conducted according to GLP.
	Chromosomal Aberrations <i>in vivo</i>	Negative for micronucleated polychromatic erythrocytes in B6C3F1 mice.	NTP, 2011; ECHA, 2013	Reported in a secondary source.
	DNA Damage and Repair	Negative for unscheduled DNA synthesis assay in Sprague Dawley rats at 10, 50, 100, 500 or 1,000 µg/mL.	IPCS, 1995	Reported in a secondary source.
	Other (Mitotic Gene Conversion)	Negative, unscheduled DNA synthesis, rat hepatocytes.	Submitted confidential study	Reported in a submitted confidential study; Study conducted according to GLP.
Reproductive Effects		MODERATE: Estimated to have potential for reproductive effects based on the potential for alkylation and professional judgment.		
	Reproduction/ Developmental Toxicity Screen	There is potential for reproductive effects based on a mechanistic consideration of the potential for alkylation (Estimated)	Professional judgment	Based on mechanistic considerations.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects			No data located.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Developmental Effects		MODERATE: Estimated to have potential for developmental effects based on the potential for alkylation and professional judgment.		
	Reproduction/ Developmental Toxicity Screen	There is potential for developmental effects based on a mechanistic consideration of the potential for alkylation (Estimated)	Professional judgment	Based on mechanistic considerations.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development			No data located.
	Postnatal Development			No data located.
Neurotoxicity		LOW: Estimated not to have potential for neurotoxicity based on expert judgment; no data located.		
	Neurotoxicity Screening Battery (Adult)	Low potential for neurotoxicity. (Estimated)	Expert judgment	Estimated based on expert judgment.
Repeated Dose Effects		MODERATE: There is potential for liver toxicity because TBBPA bis (2,3-dibromopropyl) ether is a highly brominated compound and potential for immunotoxicity associated with polyhalogenated aromatic hydrocarbon structure. Located data were insufficient.		
		Potential for liver effects based on a mechanistic consideration of this highly brominated compound (Estimated)	Professional judgment	Based on closely related confidential analogs with similar structures and functional groups.
		Mice were administered TBBPA bis (2,3-dibromopropyl) ether in their diet at 200 or 2,000 mg/kg-day for 90 days. No deaths, or abnormal symptoms observed in gross pathological examination. NOAEL = 2,000 mg/kg-day (highest dose tested)	IPCS, 1995; ECHA, 2013	Limited study details reported in a secondary source. Reported study details were not sufficient to evaluate the study quality and were considered insufficient to determine a hazard designation.
		Potential for immunotoxicity based on polyhalogenated aromatic hydrocarbons structure.	EPA, 2011a; Professional judgment	Estimated based on the presence of a structural alert.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Skin Sensitization		LOW: Not a skin sensitizer in guinea pigs. There is potential for skin sensitization based on the potential for alkylation.		
	Skin Sensitization	There is potential for skin sensitization based on a mechanistic consideration of the potential for alkylation. (Estimated by analogy)	Professional judgment	Based on mechanistic considerations.
		Not sensitizing, guinea pigs	Submitted confidential study; ECHA, 2013	Reported in a submitted confidential study; Study conducted according to GLP.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Minimal eye irritation in rabbits clearing within 48 hours.		
	Eye Irritation	Low potential for eye irritation. (Estimated)	Expert judgment	Estimated based on expert judgment.
		Workers report development of eye irritation following exposure to a complex mixture of airborne contaminants that included TBBPA bis (2,3-dibromopropyl) ether.	Great Lakes Chemical Corporation, 1999	Evidence is based on isolated incidents and workers were exposed to a complex mixture of airborne contaminants while melt processing that uses thermoplastic resin formulators containing this substance as an additive.
		Minimal irritation, rabbits; irritation was reversed within 24-48 hours.	Submitted confidential study; ECHA, 2013	Reported in a submitted confidential study; Study conducted according to GLP and OECD guidelines.
Dermal Irritation		LOW: Not a skin irritant in rabbits.		
	Dermal Irritation	Low potential for dermal irritation. (Estimated)	Expert judgment	Estimated based on expert judgment.
		Negative, rabbits	Submitted confidential study; ECHA, 2013	Reported in a submitted confidential study; Study conducted according to GLP and OECD guidelines.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Workers report development of dermal irritation following exposure to a complex mixture of airborne contaminants that included TBBPA bis (2,3-dibromopropyl) ether.	Great Lakes Chemical Corporation, 1999	Evidence is based on isolated incidents and workers were exposed to a complex mixture of airborne contaminants while melt processing that uses thermoplastic resin formulators containing this substance as an additive.
Endocrine Activity		Based on 4 <i>in vitro</i> assays, TBBPA bis (2,3-dibromopropyl) ether can interact with the endocrine system. TBBPA bis (2,3-dibromopropyl) ether may have potential estrogenic and transthyretin-binding effects. TBBPA bis (2,3-dibromopropyl) ether appears to inhibit sulfation of estradiol (E2), but does not exhibit estrogenic activity via interference with estrogen receptors (ER). TBBPA bis (2,3-dibromopropyl) ether also does not appear to interfere with AhR-mediated, androgenic or progestagenic pathways. TBBPA bis (2,3-dibromopropyl) ether competed with thyroid hormone precursor thyroxine (T4) for binding to human transthyretin (TTR), but did not exhibit thyroid hormone (T3) mimicking activity.		
		Negative; did not cause inhibition of CYP17 catalytic activity in human H295R adrenocortical carcinoma cells.	Cantón et al., 2006	Data taken from primary study.
		Positive for estradiol sulfotransferase (E2SULT)-enzyme inhibition in E2SULT assay.	Hamers et al., 2006	Data taken from primary study.
		Negative for agonistic and antagonistic interactions with aryl hydrocarbon (AhR), androgen (AR), progesterone (PR), and estrogen (ER) receptors in series of CALUX assays.	Hamers et al., 2006	Data taken from primary study.
		Positive for displacement of thyroid hormone precursor thyroxine (T4) from plasma transport protein in TTR binding assay.	Hamers et al., 2006	Data taken from primary study.
		Negative for potentiating and antagonistic activity with T3-mediated cell proliferation in T-screen.	Hamers et al., 2006	Data taken from primary study.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Immunotoxicity		Potential for immunotoxicity based on the presence of polyhalogenated aromatic hydrocarbon structure and professional judgment.		
	Immune System Effects	Potential for immunotoxicity based on the presence of polyhalogenated aromatic hydrocarbon structure. (Estimated)	EPA, 2011; Professional judgment	Estimated based on the presence of a structural alert.
ECOTOXICITY				
ECOSAR Class		Halo ethers		
Acute Toxicity		LOW: Based on experimental and estimated acute toxicity values for fish, daphnid, and algae that suggest no effects at saturation (NES).		
Fish LC₅₀		Fish 96-hour LC ₅₀ = 1.5x10 ⁻⁵ mg/L (Estimated) ECOSAR: Halo ethers	ECOSAR version 1.11	NES: The log K _{ow} of 12 for this chemical exceeds the structure activity relationship (SAR) limitation for log K _{ow} of 5.0; NES are predicted.
		Fish 96-hour LC ₅₀ = 2.2x10 ⁻⁶ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 12 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
		Fish (<i>Oryzias latipes</i>) 96-hour LC ₅₀ > 500 mg/L; Semi-static conditions.	ECHA, 2013	Sufficient study details reported in a secondary source. GLP study conducted using OECD and Japanese guidelines. The value exceeds the estimated water solubility; NES are predicted.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish (<i>Oncorhynchus mykiss</i>) 96-hour LC ₅₀ > 100 mg/L; Static conditions.	ECHA, 2013	Sufficient study details reported in a secondary source. GLP study conducted using OECD guidelines. The value exceeds the estimated water solubility; NES are predicted.
Daphnid LC₅₀	Daphnia 48-hour LC ₅₀ = 3.01x10 ⁻⁶ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 12 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0; NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
	Daphnia magna 48-hour EC ₅₀ > 100 mg/L; Water accommodated fraction (WAF) nominal concentration.	ECHA, 2013	Sufficient study details reported in a secondary source. GLP study conducted using OECD guidelines. The value exceeds the estimated water solubility; NES are predicted.
Green Algae EC₅₀	Green algae 96-hour EC ₅₀ = 8.48x10 ⁻⁵ mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 12 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4; NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae (<i>Pseudokirchnerella subcapitata</i>) 48 and 72-hour EC ₅₀ (growth rate/biomass) > 100 mg/L; WAF nominal concentration.	ECHA, 2013	Sufficient study details reported in a secondary source. GLP study conducted using OECD guidelines. The value exceeds the estimated water solubility; NES are predicted.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Chronic Aquatic Toxicity	LOW: Based on estimated chronic toxicity values for fish, daphnid and green algae that suggest NES.		
Fish ChV	Fish ChV = 8.78×10^{-7} mg/L (Estimated) ECOSAR: Halo ethers	ECOSAR version 1.11	NES: The log K _{ow} of 12 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted.
	Fish ChV = 6.6×10^{-7} mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 12 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
Daphnid ChV	Daphnid ChV = 3.38×10^{-6} mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 12 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Green Algae ChV		Green Algae ChV = 0.000157 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The log K _{ow} of 12 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0; NES are predicted. Narcosis classes (neutral organics) are provided for comparative purposes; DfE assessment methodology will use the lowest estimated toxicity value provided by ECOSAR classes that have a more specific mode of action relative to narcosis.
ENVIRONMENTAL FATE				
Transport		Evaluation of TBBPA bis (2,3-dibromopropyl) ether transport is based entirely on estimations from quantitative structure activity relationships. TBBPA bis (2,3-dibromopropyl) ether is expected to have low mobility in soil based on estimations indicating strong absorption to soil. If released to the atmosphere, TBBPA bis (2,3-dibromopropyl) ether is likely to exist solely as particulate. As a particulate, atmospheric oxidation is not expected to be a significant route of environmental removal. Based on the Henry's Law Constant, volatilization from water or moist soil is not expected to occur at an appreciable rate. Level III fugacity models indicate that TBBPA bis (2,3-dibromopropyl) ether will partition predominantly to sediment and soil.		
	Henry's Law Constant (atm-m³/mole)	<10 ⁻⁸ (Estimated)	EPI; Professional judgment	Cutoff value for nonvolatile compounds.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	>30,000 (Estimated)	EPI; EPA, 1999	Cutoff value for nonmobile compounds according to HPV assessment guidance.
		>30,000 (Measured) Reported as log K _{oc} >>5.63at 25°C; OECD TG 121: Estimation of Adsorption Coefficient on Soil and Sewage Sludge (HPLC); GLP-study	ECHA, 2013	Guideline study reported in a secondary source, although the experimental values were outside the scope of the protocol (log K _{oc} 1.5-5.0); radiochemical purity of test substance (TBBA-bis(2,3-dibromopropyl ether)) >99%.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		>30,000 (Measured) Reported as log K _{OC} values of 6.1 (soil) and 7.6 (sludge) at pH 7.0; OECD Guideline 121: Estimation of Adsorption Coefficient on Soil and Sewage Sludge (HPLC); GLP-study	ECHA, 2013	Guideline study reported in a secondary source, although the experimental values were outside the scope of the protocol (log K _{OC} 1.5-5.0); purity of test substance (FR-720) not stated.
	Level III Fugacity Model	Air: <1% (Estimated) Water = 5% Soil = 95% Sediment: <1%	EPI	
Persistence		VERY HIGH: High persistence of TBBPA bis (2,3-dibromopropyl) ether is expected as a result of located biodegradation studies and the absence of other expected likely removal processes under environmental conditions. In the course of a 28-day Japanese Ministry of International Trade and Industry (MITI) test, only 1% of TBBPA bis (2,3-dibromopropyl) ether was degraded. TBBPA bis (2,3-dibromopropyl) ether will exist primarily in the particulate phase in the atmosphere and is not expected to undergo removal by gas phase oxidation reactions. It is also not anticipated to undergo removal by hydrolysis.		
Water	Aerobic Biodegradation	1% after 4 weeks OECD 301C; test concentration of 100 mg/L and concentration of activated sludge inoculum of 30 mg/L (Measured)	MITI, 2007	Adequate, guideline study.
		Passes Ready Test: No Test method: OECD TG 301B: CO ₂ Evolution Test 1% degradation after 29 days using an activated sludge inoculum. (Measured)	ECHA, 2013	Adequate, guideline study reported in a secondary source; purity of test substance FR-720 is 95%.
	Volatilization Half-life for Model River	>1 year (Estimated)	EPI	
	Volatilization Half-life for Model Lake	>1 year (Estimated)	EPI	

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Soil	Aerobic Biodegradation	0% degradation after 120 days in soil; OECD TG 307: Aerobic and Anaerobic Transformation in Soil; test concentration of 70.0 kBq/40 g soil dry weight; GLP-study (Measured)	ECHA, 2013	Adequate guideline study reported in a secondary source with ¹⁴ C-TBBPA-DBPE. No transformation products were observed; degradation assessed with 4 different soil types.
	Anaerobic Biodegradation	0% degradation after 100 days in natural sediment; OECD TG 308: Aerobic and Anaerobic Transformation in Aquatic Sediment Systems; GLP-study (Measured)	ECHA, 2013	Adequate, guideline study reported in a secondary source with ¹⁴ C-TBBPA-DBPE. Degradation results assessed with 2 sediment types, material mass balance was reported for both types: 1.98% in water and 84.48% in sediment.
	Soil Biodegradation w/ Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	12 hours (Estimated)	EPI	
Reactivity	Photolysis			No data located.
	Hydrolysis	50% > 1 year at 50°C and pH 4, 7, and 9 OECD TG 111: Hydrolysis as a function of pH and OPPTS 835.21 10: Hydrolysis as a function of pH; GLP study		Adequate, guideline study reported in a secondary source. Test substance purity (PE-68; CASRN 21850-44-2) not stated, no degradation was observed after 5 days in triplicate samples prepared for each pH level. The substance does not contain functional groups that would be expected to hydrolyze readily under environmental conditions.
Environmental Half-life		>180 days (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.

Tetrabromobisphenol A Bis (2,3-dibromopropyl) Ether CASRN 21850-44-2

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Aquatic mesocosm study; a controlled source of TBBPA bis (2,3-dibromopropyl) ether was applied and analyzed by GC-MS over the course of the study. TBBPA bis (2,3-dibromopropyl) ether was detected in both the particulate and sediment compartments. Degradation products were detected but not all were identified. (Measured)	de Jourdan, et al., 2013	Nonguideline field study providing supporting data about the partitioning and fate/persistence of this compound under environmental conditions.
Bioaccumulation		HIGH: Based on an estimated BAF of 12,000 and its detection in Great Lakes Herring gull eggs, potential for bioaccumulation is high.		
	Fish BCF	3.4 to 43 (15 µg/L concentration) <17 to 130 (1.5 µg/L concentration) (Measured)	MITI, 2007	Adequate, guideline study.
	BAF	12,000 (Estimated)	EPI	
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		TBBPA bis (2,3-dibromopropyl) ether was identified in dust collected near an artificial stream and pond system in Berlin, Germany (Harju et al., 2009); in sewage sludge samples from southern China; in sediments from southern China (Shi et al., 2009) and in water, sediment and soil along the Liuyang River in China (Qu et al., 2011).		
Ecological Biomonitoring		Detected in Great Lakes Herring gull eggs (Letcher and Chu, 2010).		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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Triphenyl Phosphate

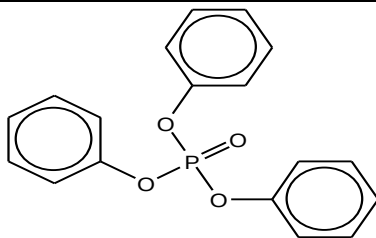
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Triphenyl Phosphate	115-86-6	L	M	L	L	L	L	H	L		L	VL	VH	VH	L	M

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Triphenyl Phosphate



CASRN: 115-86-6

MW: 326.29

MF: C₁₈H₁₅O₄P

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: O=P(Oc1ccccc1)(Oc1ccccc1)Oc1ccccc1

Synonyms: Phosphoric acid, triphenyl ester; TPP

Chemical Considerations: This is a discrete organic chemical with a MW <1,000. EPI v 4.0 was used to estimate physical/chemical and environmental fate values due to an absence of experimental data. Measured values from experimental studies were incorporated into the estimations.

Polymeric: No

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: Diphenyl phosphate (CASRN 838-85-7) and phenol (CASRN 108-95-2)

Analog: No analog

Endpoint(s) using analog values: Not applicable

Analog Structure: Not applicable

Structural Alerts: Organophosphates; Neurotoxicity (EPA, 2012).

Risk Phrases: R50/53: Very toxic to aquatic organisms. May cause long-term adverse effects in the aquatic environment (OECD SIDS, 2002).

Hazard and Risk Assessments: Design for the Environment (DfE) Alternatives Assessment for Furniture Flame Retardancy Partnership, September, 2005 (EPA, 2005)

Triphenyl Phosphate CASRN 115-86-6			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	50.5 (Measured)	Lide, 2008	Adequate.
	49 Reported as 49-50°C (Measured)	EC, 2000	Reported in a secondary source; consistent with value reported in primary source.
Boiling Point (°C)	245 Reported at 11 mmHg (Measured)	O'Neil, 2006	Adequate.
	>300 (Estimated)	EPI; EPA, 1999	Cutoff value for high boiling point compounds according to High Production Volume assessment guidance.
	220 Reported at 5 mmHg (Measured)	EC, 2000	Reported in a secondary source; consistent with value reported in primary source.
Vapor Pressure (mm Hg)	6.28x10 ⁻⁶ (Extrapolated)	Dobry and Keller, 1957	Adequate.
	1.5x10 ⁻⁶ (Measured)	EC, 2000	Reported in a secondary source.
Water Solubility (mg/L)	1.9 (Measured)	Saeger et al., 1979	Adequate.
	0.75 (Measured) OECD Guideline 105	EC, 2000	Guideline study reported in a secondary source.
	0.025 (Measured)	EC, 2000	Reported in a secondary source; not consistent with other measured values.
Log K_{ow}	4.59 (Measured)	Hansch and Leo, 1995	Adequate.
	4.76 (Measured)	OECD SIDS, 2002	Reported in a secondary source; consistent with value reported in primary source.
Flammability (Flash Point)	220°C (Measured)	Lewis, 2001	Adequate.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.

Triphenyl Phosphate CASRN 115-86-6				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pH		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
pK _a		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
HUMAN HEALTH EFFECTS				
Toxicokinetics		Triphenyl phosphate is hydrolyzed in the liver to produce diphenyl phosphate as the primary metabolite. TPP can be detected in human breast milk.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Triphenyl phosphate is hydrolyzed in rat liver homogenate to produce the metabolite diphenyl phosphate. (Measured)	OECD SIDS, 2002	Reported in a secondary source.
	Other	TPP concentrations in milk were analyzed in a human cohort study conducted between 1997 and 2007. Median concentration across all subjects was 8.5 ng/g (min-max values: 3.2-11 ng/g).	ECHA, 2012	Limited study details reported in a secondary source.
Acute Toxicity		LOW: Oral LD ₅₀ in rats and mice is >5,000 mg/kg and the dermal LD ₅₀ in rabbits is >7,900 mg/kg. No adequate data were located to assess the toxicity of inhalation exposure.		
Acute Lethality	Oral	Rat, mouse, oral LD ₅₀ >5,000 mg/kg	OECD SIDS, 2002	Reported in a secondary source.
		Several rat, oral, LD ₅₀ >6,400 mg/kg	ATSDR, 2009	Reported in a secondary source.
	Dermal	Rabbit dermal LD ₅₀ >10,000 mg/kg	OECD SIDS, 2002	Reported in a secondary source.
		Rabbit dermal LD ₅₀ >7,900 mg/kg	ATSDR, 2009	Reported in a secondary source.
	Inhalation	Rat LC ₅₀ >200,000 mg/m ³ (dust), 1-hour exposure, 14-day observation	ATSDR, 2009	Reported in a secondary source. Insufficient exposure time (1 hour), no data on method or good laboratory practice.
Carcinogenicity		MODERATE: OncoLogic modeling indicates a marginal to low potential for carcinogenicity. No long-term carcinogenicity assays were found.		
	OncoLogic Results	Marginal to Low (Estimated)	OncoLogic, 2008	

Triphenyl Phosphate CASRN 115-86-6

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Carcinogenicity (Rat and Mouse)	Mouse lung adenoma test: Male A/St mice (20/group) received IP injections of either 20 mg/kg (18/6 weeks); 40 mg/kg (3/1 week); or 80 mg/kg. No significant increase in incidence of adenoma compared to negative controls, and positive control (urethane) produced 19.6 tumors/mouse with 100% survival.	OECD SIDS, 2002	Reported in a secondary source. Nonstandard study, limited histopathology and short-duration, reported in a secondary source.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		LOW: Triphenyl phosphate was not mutagenic in bacteria or mammalian cells <i>in vitro</i> and did not cause chromosomal aberrations in vitro. In addition, triphenyl phosphate did not result in DNA damage in hamster fibroblast cells.		
	Gene Mutation <i>in vitro</i>	Negative, Ames assay in <i>Salmonella typhimurium</i> strains TA98, TA100, TA1537, TA1538 with and without metabolic activation.	ATSDR, 2009; ECHA, 2012	Reported in a secondary source.
		Negative, forward mutation assay in mouse lymphoma L5178Y cells.	OECD SIDS, 2002; ECHA, 2012	Reported in a secondary source.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative in chromosome aberration test in Chinese hamster V79 cells; with and without metabolic activation.	ECHA, 2012	Reported in a secondary source.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair	Negative, unscheduled DNA synthesis in hamster fibroblast cells.	OECD SIDS, 2002	Reported in a secondary source.
	Other (Mitotic Gene Conversion)	Negative, mitotic gene conversion assay in <i>Saccharomyces cerevisiae</i> with and without activation.	OECD SIDS, 2002	Reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		LOW: Based on a rat oral reproductive/developmental NOAEL = 690 mg/kg-bw/day for reproductive effects (highest dose tested). In addition, no histopathological effects on reproductive organs were reported following 3 weeks of dermal exposure in rabbits. Correlation of TPP in house dust and decreased sperm counts in humans has been reported, however rat studies did not measure the same endpoint, so there are insufficient data for this effect.		
	Reproduction/ Developmental Toxicity Screen	Reproductive/developmental dietary study (91 days pre mating and continuing through gestation), 40 male and 40 female rats/group, test compound concentrations of 0, 0.25, 0.50, 0.75, or 1.0% (~0, 166, 341, 516 or 690 mg/kg-bw/day, respectively). No signs of parental toxicity, no reproductive effects (number pregnant, corpora lutea, implantations, implantation efficiency, resorptions). NOAEL (reproductive effects) = 690 mg/kg-bw/day (highest dose tested) LOAEL = not identified; there were no effects at the highest dose tested.	OECD SIDS, 2002; ATSDR, 2009	Reported in a secondary source. A LOAEL was not identified; there were no effects at the highest dose tested.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects	Rabbits, dermal (clipped, intact), 5x/week, 3 weeks, 50% solution in ethanol; no effect on the reproductive organs reported up to the highest dose tested (1,000 mg/kg/day) NOAEL = 1,000 mg/kg/day	OECD SIDS, 2002	Reported in a secondary source. Organs examined by histopathology; there were no effects at the highest dose tested; dermal repeated-dose study.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Other	Men living in homes with higher amounts of TPP in house dust had reduced sperm count and altered hormone levels related to fertility and thyroid function. Each interquartile range (IQR) TPP increase in house dust samples was associated with a 19% decrease in sperm concentrations and a 10% increase in prolactin levels.	Betts, 2010; Meeker and Stapleton, 2010	The actual exposure to TPP is unknown; it is not known if TPP or other substances found in the household dust caused or contributed to the reported toxicity.
Developmental Effects		LOW: Based on a rat oral reproductive/developmental NOAEL = 690 mg/kg-bw/day for fetal effects (highest dose tested). There were no data located for the developmental neurotoxicity endpoint. Decreased cholinesterase activity in pregnant lab animals has been shown to have a negative impact on fetal brain development. As a result, there is uncertain potential for developmental neurotoxicity for this substance.		
	Reproduction/ Developmental Toxicity Screen	Reproductive/developmental (dietary) study, 91 days pre-mating (males and females), continuing through gestation and lactation (females only), 40 male and 40 female rats/group, test compound concentrations of 0, 0.25, 0.50, 0.75, or 1.0% (~0, 166, 341, 516 or 690 mg/kg-bw/day, respectively), no effects on fetal endpoints (viability, early or late deaths, fetal weight, length or distribution) or skeletal anomalies. NOAEL (developmental effects) = 690 mg/kg-bw/day	OECD SIDS, 2002; ATSDR, 2009	Reported in a secondary source. A LOAEL was not identified; there were no effects at the highest dose tested.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development			No data located.
	Postnatal Development			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Developmental Neurotoxicity	There were no data located for the developmental neurotoxicity endpoint. Decreased cholinesterase activity in pregnant lab animals has been shown to have a negative impact on fetal brain development. As a result, there is uncertain potential for developmental neurotoxicity for this substance.	Professional judgment	No data located.
	Other			No data located.
Neurotoxicity		LOW: Based on an adult rat neurotoxicity screening battery NOAEL = 711 mg/kg-bw/day; all other experimental results are consistent with this hazard designation.		
	Acute and 28-day Delayed Neurotoxicity of Organophosphorus Substances (Hen)	Two female hens/dose in delayed neurotoxicity test, gavage, 2,000, 3,000, 5,000, 8,000, or 12,500 mg/kg, no signs of toxicity in-life or at necropsy NOAEL $\geq$ 12,500 mg/kg	OECD SIDS, 2002	Reported in a secondary source. No data on test substance purity.
		Several acute oral studies in hens, administered doses up to 12,500 mg/kg, generally found no signs of paralysis, histopathological changes in examined nerve tissues, or behavior immediately after or during observation periods of up to 36 days. However, blood cholinesterase was decreased by up to 87% in studies where it was measured. NOAEL >12,500 mg/kg	OECD SIDS, 2002	Reported in a secondary source. No data on test substance purity.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Neurotoxicity Screening Battery (Adult)	4-month dietary study, 10 rats/dose, 0.25, 0.5, 0.75 or 1% test concentration (161, 345, 517 or 711 mg/kg-bw/day, respectively), no neurobehavioral effects (open field, accelerating rotarod, forelimb grip strength and negative geotaxis examinations). NOAEL = 711 mg/kg-bw-day (highest dose tested)	ATSDR, 2009	Reported in a secondary source.
	Other	There is potential for neurotoxic effects based on a structural alert for organophosphates (Estimated)	Professional judgment	Estimated based on a structural alert for organophosphates and professional judgment.
Repeated Dose Effects		HIGH: Based on weight of evidence including reduced body weight in male rats administered triphenyl phosphate in the diet for 28 days. The NOAEL of 23.5 mg/kg-day and the LOAEL of 161.4 mg/kg-day span across the High and Moderate hazard designation ranges (DfE criteria are for 90-day repeated dose studies; criteria values are tripled for chemicals evaluated in 28-day studies making the High hazard range < 30 mg/kg-day and the Moderate hazard range between 30 and 300 mg/kg-day).		
		28-day repeated dose oral exposure study in rats. 0, 250, 1,000, 4,000 ppm in diet. Effects on body weights were observed Male: NOAEL = 250 ppm (23.5 mg/kg-day) LOAEL = 1,000 ppm (161.4 mg/kg-day)	ECHA, 2012	Reported in secondary source. DfE criteria are for 90-day repeated dose studies. Criteria values are tripled for chemicals evaluated in 28-day studies.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	35-day repeated-dose oral (dietary) study, 5 male rats/group, test compound concentrations of 0, 0.5, and 5.0% (~0, 350, and 3,500 mg/kg-day, respectively), with a 0.1% (~70 mg/kg-day) dose replacing the high dose group after 3 days. Slight reduction in body weight gain and increase in liver weight in 350 mg/kg-day dose group. NOAEL = 70 mg/kg-day LOAEL = 350 mg/kg-day	OECD SIDS, 2002	Reported in a secondary source. Limited study details provided.
	4-month repeated-dose dietary study, Sprague-Dawley rats, 10 rats/dose, 0.25, 0.5, 0.75 or 1% test concentration (161, 345, 517 or 711 mg/kg-bw/day, respectively), reduced body weight gain (11%) at 345 mg/kg-bw/day. NOAEL = 161 mg/kg-bw/day LOAEL = 345 mg/kg-bw/day	ATSDR, 2009	Reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	21-day repeated-dose dermal study, 10 male and 10 female rabbits/group, test compound concentrations of 0, 100, and 1,000 mg/kg-bw/day, no mortality, clinical symptoms, or changes in body weight, hematology, clinical chemistry, necropsy, organ weights and histopathology reported; only decreased acetyl cholinesterase levels in plasma, erythrocytes and brain were reported and not considered to be of toxicological relevance as there was no clinical or histological correlation. NOAEL = 1,000 mg/kg-bw/day	OECD SIDS, 2002	Reported in a secondary source. Treatment period only 21 days.
	In a 3-month study, rats were orally gavaged with test substances at 0, 380 and 1900 mg/kg-day. No toxic effects were observed. NOEL: 1900 mg/kg-day; highest dose tested LOEL: Not established	ATSDR, 2009	Limited study details reported in a secondary source. Primary source is an abstract with few experimental

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Immune System Effects	120-day dietary study, rats, 0, 0.25, 0.5, 0.75, and 1% of triphenyl phosphate (~0, 161, 345, 517 and 711 mg/kg-bw/day); initial, secondary, and tertiary immunizations with sheep red blood cells performed at 60, 81, and 102 days, respectively. No significant effects were reported on the weight and histopathology of the spleen, thymus and lymph nodes, and no significant changes to the humoral response were reported.	ATSDR, 2009	Reported in a secondary source.
		NOEL = 711 mg/kg/day		
		Rabbits exposed to up to 1,000 mg/kg-bw/day, applied 5 days/week for 3 weeks to intact or abraded skin, had no gross or microscopic effects on the spleen, thymus, or lymph nodes.	ATSDR, 2009	Reported in a secondary source.
Skin Sensitization		LOW: Based on an experimental study in guinea pigs indicating that triphenyl phosphate is not a skin sensitizer.		
	Skin Sensitization	Several human case studies have reported allergic dermatitis; 15 of 23,192 (0.065%) human volunteers patch tested from 1950 to 1962 had positive reactions to cellulose acetate film containing 7-10% triphenyl phosphate and 3-4% phthalic esters.	OECD SIDS, 2002	Reported in a secondary source. Limited study details provided; patch tests conducted with mixtures; unclear which component of mixture caused low incidence of sensitization.
		A confidential skin sensitization study with negative results in guinea pigs.	Confidential study	Reported in a confidential study.
		None of the patients tested in two separate studies of 343 and 174 patients, respectively, had sensitization reactions to triphenyl phosphate.	OECD SIDS, 2002	Reported in a secondary source. Limited study details provided.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Not sensitizing, guinea pig maximization test	OECD SIDS, 2002	Study reported in a secondary source; conducted according to OECD Guideline 406.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Triphenyl phosphate is mildly irritating to rabbit eyes with effects clearing within 72 hours.		
	Eye Irritation	Not irritating, rabbits	OECD SIDS, 2002	Study reported in a secondary source; conducted according to OECD Guideline 405.
		Mild irritation in rabbit eyes, clearing within 72 hours.	OECD SIDS, 2002	Reported in a secondary source.
Dermal Irritation		VERY LOW: Triphenyl Phosphate is not a skin irritant in rabbits.		
	Dermal Irritation	Not irritating, rabbits; semi-occlusive or occlusive conditions for 4, 24, or 72 hours	OECD SIDS, 2002	Study reported in a secondary source; conducted according to OECD Guideline 404.
		Non-irritant, rabbit	ATSDR, 2009	Reported in a secondary source.
Endocrine Activity		Triphenyl phosphate was found to be inactive in an estrogen-receptor binding assay; however, it was shown to be a moderate androgen-receptor (AR) binder in a competitive binding assay. Triphenyl phosphate was shown to inhibit human AR in the absence of agonist and to inhibit testosterone-induced AR activity. In addition, triphenyl phosphate significantly impaired reproduction in zebrafish and was correlated with decreased sperm count and altered hormone levels in men.		
		21-day reproduction study in zebrafish. Significant decrease in fecundity, significant increases of plasma 17B-estradiol (E2) concentrations, vitellogenin (VTG) levels, and E2/testosterone (T) and E2/11-ketotestosterone (11-KT) ratios. Sex-dependent changes in transcriptional profiles of several genes of the hypothalamus-pituitary-gonad (HPG) axis.	Liu et al., 2013	Adequate primary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Study conducted to determine effects of triaryl phosphates on mouse and human nuclear receptors. Mouse constitutively active receptor (CAR) was activated by 1.3-fold following exposure to TPP. Testosterone-induced AR-dependent activity was lowered by 30-40%.	Honkakoski et al., 2004	Adequate primary source.
	Exposure to TPP in zebrafish resulted in severe pericardial edema and blocked looping of the atrium and ventricle. TPP-induced cardiotoxicity in zebrafish embryos is mediated through an AHR independent pathway.	McGee et al., 2013	Adequate primary source.
	In a luciferase reporter-gene assay using cultured cells, TPP inhibited the luciferase expression induced by dihydrotestosterone (10^{-9} M). IC ₅₀ for antiandrogenic activity = 0.000047 - 0.0006 M	Ohyama et al., 2006	Primary source in Japanese with English abstract.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Endocrine disrupting potential was investigated using human cells lines (H295R, MVLN) and zebrafish plasma. TPP was cytotoxic to H295R cells (showing <80% cell viability at ≥ 10 mg/L) and significantly increased E2 and T production. Transcription of CYP19A1 was significantly up-regulated and transcription of SULT1E1 gene was down-regulated. No binding affinity to E2 receptor in MVLN cells, but binding of E2 to ER was reduced in a dose-dependent manner. Plasma E2 was significantly increased in fish plasma and T and 11-KT were decreased (1 mg/L). Changes in transcription of steroidogenic genes and vitellogenin gene were observed.	Liu et al., 2012	Adequate, primary source.
	Men living in homes with higher amounts of TPP in house dust had reduced sperm count and altered hormone levels related to fertility and thyroid function. Each interquartile range (IQR) TPP increase in house dust samples was associated with a 19% decrease in sperm concentrations and a 10% increase in prolactin levels.	Betts, 2010; Meeker and Stapleton, 2010	The actual exposure to TPP is unknown; it is not known if TPP or other substances found in the household dust caused or contributed to the reported toxicity.
	Inactive in a binding assay with the rat uteri estrogen receptor from ovariectomized Sprague-Dawley rats	ATSDR, 2009	Reported in a secondary source.
	Moderate binding in a competitive androgen-receptor (AR) binding assay using recombinant rat protein expressed in <i>Escherichia coli</i> .	ATSDR, 2009	Reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Inhibited AR activity in COS-1 cells transfected with human AR both in the absence of agonist, as well as inhibited testosterone-induced AR activity by 30-40%.	ATSDR, 2009	Reported in a secondary source.
Immunotoxicity		Oral exposure of rats to triphenyl phosphate for 4 months and dermal exposure of rabbits for 3 weeks produced no effects on immune function parameters.		
	Immune System Effects	120-day dietary study, rats, 0, 0.25, 0.5, 0.75, and 1% of triphenyl phosphate (~0, 161, 345, 517 and 711 mg/kg-bw/day); initial, secondary, and tertiary immunizations with sheep red blood cells performed at 60, 81, and 102 days, respectively. No significant effects were reported on the weight and histopathology of the spleen, thymus and lymph nodes, and no significant changes to the humoral response were reported. NOEL = 711 mg/kg/day	ATSDR, 2009	Reported in a secondary source.
		Rabbits, up to 1,000 mg/kg-bw/day, applied 5 days/week for 3 weeks to intact or abraded skin had no gross or microscopic effects on the spleen, thymus, or lymph nodes.	ATSDR, 2009	Reported in a secondary source.
ECOTOXICITY				
ECOSAR Class		Esters (phosphate), Esters		
Acute Toxicity		VERY HIGH: Based on experimental fish 96-hour LC ₅₀ values of 0.4 and 0.85 mg/L.		
Fish LC ₅₀		Fish 96-hour LC ₅₀ = 0.4 mg/L (Experimental)	OECD SIDS, 2002	Reported in a secondary source.
		Fish 96-hour LC ₅₀ = 0.85 mg/L (Experimental)	OECD SIDS, 2002	Reported in a secondary source. Guideline study.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Fish 96-hour LC ₅₀ = 290 mg/L (Experimental)	OECD SIDS, 2002	Limited study details reported in a secondary source. The study does not meet important criteria for standard methods (e.g. test substance concentration at solubility threshold in water).
	Fish 96-hour LC ₅₀ = 1.62 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Daphnid LC₅₀	Daphnid 48-hour LC ₅₀ = 1.28 mg/L (Experimental)	FMC Industrial Chemical Division, 1979	Sufficient study details reported.
	Daphnid 48-hour EC ₅₀ = 1.35 mg/L (Experimental)	OECD SIDS, 2002	Study reported in a secondary source; conducted according to US EPA 660/3-75-009.
	Daphnid 48-hour LC ₅₀ = 1.28 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
	Daphnid 48-hour LC ₅₀ = 1.0 mg/L (Experimental)	Mayer et al., 1981	Sufficient study details reported.
Other Freshwater Invertebrate LC₅₀	<i>Mysidopsis bahia</i> 96-hour LC ₅₀ >0.18 - 0.32 mg/L (Experimental)	OECD SIDS, 2002	Reported in a secondary source.
Green Algae EC₅₀	Green algae 96-hour EC ₅₀ = 2.0 mg/L (Experimental)	OECD SIDS, 2002	Reported in a secondary source.
	Green algae 96-hour EC ₅₀ = 2.0 mg/L (Experimental)	Mayer et al., 1981	Sufficient study details reported

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Green algae (<i>Scenedesmus subspicatus</i>) 72-hour LOEC = 0.5 - 5 mg/L NOEC = 0.25 - 2.5 mg/L (Experimental)	OECD SIDS, 2002	Study reported in secondary source; conducted according to OECD guideline 201.
	Green algae 96-hour EC ₅₀ = 1.59 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Chronic Aquatic Toxicity	VERY HIGH: Based on an experimental fish 30-day LOEC = 0.037 mg/L. No chronic experimental data were available for daphnia or algae.		
Fish ChV	Fish 30-day LOEC = 0.23 mg/L (Experimental)	OECD SIDS, 2002	Reported in a secondary source. Guideline study.
	<i>Oncorhynchus mykiss</i> 30-day LOEC = 0.037 mg/L (Experimental)	ECHA, 2012	Reported in a secondary source.
	Fish ChV = 0.15 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Daphnid ChV	Daphnid ChV = 0.186 mg/L (Estimated) ECOSAR: Neutral organic	ECOSAR version 1.11	ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Green Algae ChV	Green algae ChV = 0.925 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
ENVIRONMENTAL FATE				
Transport		Level III fugacity models incorporating available physical and chemical property data indicate that at steady state TPP is expected to be found primarily in soil and to a lesser extent, water. Triphenyl phosphate is expected to have moderate mobility in soil, based on measured K_{oc} values in silty clay, loamy sand and silt loam. Leaching through soil to groundwater may occur, though it is not expected to be an important transport mechanism. Triphenyl phosphate may volatilize from moist soil and water surfaces based on its Henry's Law constant. Volatilization from dry surface is not expected based on its vapor pressure. In the atmosphere, triphenyl phosphate is expected to exist in both the vapor phase and particulate phase. Particulates may be removed from air by wet or dry deposition.		
	Henry's Law Constant (atm-m³/mole)	1.2x10 ⁻⁵ (Measured)	Mayer et al., 1981; Huckins et al., 1991	Adequate.
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	2,514–3,561 in silty clay, loamy sand and silt loam (Measured)	Anderson et al., 1993	Adequate.
	Level III Fugacity Model	Air: <1% (Estimated) Water = 15% Soil = 75% Sediment = 9.6%	EPI	Reported in a Level III Fugacity model. Experimental data is consistent with partitioning to sediment.
Persistence		LOW: The persistence of triphenyl phosphate is based on experimental data. Under aerobic conditions in a Japanese MITI ready biodegradability test (OECD Test Guidelines (TG) 301C), 90% biodegradation of triphenyl phosphate occurred after 28 days, and 93.8% triphenyl phosphate removal as dissolved organic carbon (DOC) occurred over 20 days in an OECD 303A guideline study. TPP does not meet the criteria for very low persistence because the percent removal in the criteria does not occur within a 10-day window. In loamy sand, a half-life of 37 days was observed under aerobic conditions. Triphenyl phosphate was determined to be inherently biodegradable in a river die-away test, after degrading 100% over 3 days in river water. Triphenyl phosphate may degrade under anaerobic conditions, with primary degradation of 31.1% after 3 days (89.7% after 40 days) in river sediment. However, removal under anaerobic conditions is not anticipated to be an important fate process. Triphenyl phosphate will undergo hydrolysis under alkaline conditions, with half-lives of 3 days at pH 9; it is relatively stable to hydrolysis under neutral and acidic conditions, with half-lives of 28 days at pH 5 and 19 days at pH 7. Triphenyl phosphate is not expected to be susceptible to direct photolysis by sunlight, since it does not absorb light at wavelengths >290 nm. The atmospheric half-life of vapor-phase triphenyl phosphate is estimated to be 12 hours.		

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Water	Aerobic Biodegradation	Inherently Biodegradable: Degraded 100% after 3 days in river water (River die-away test) (Measured)	OECD SIDS, 2002	Adequate, guideline study.
		Passes Ready Test: Yes Test method: OECD TG 301C: Modified MITI Test (I) 83-94% biodegradation after 28 days at 100 mg/L of test substance. (Measured)	OECD-SIDS, 2002	Reported in a guideline study.
	Volatilization Half-life for Model River	13 days (Estimated)	EPI	
	Volatilization Half-life for Model Lake	150 days (Estimated)	EPI	
Soil	Aerobic Biodegradation	Study results: 93.8%/20 days Test method: 303A: Activated Sludge Units - Simulation Test Removal as DOC, using initial concentration of 5 mg/L with activated sludge. Reported as inherently biodegradable. (Measured)	OECD SIDS, 2002; EC, 2000	Adequate, guideline study.
		Study results: 77%/28 days Test method: Other Reported as ultimately biodegradable. Monsanto Shake Flask Procedure (precursor to Closed bottle test). (Measured)	OECD SIDS, 2002	Reported in a secondary source.
		Study results: 82%/28 days Test method: CO2 Evolution Modified Sturm test. Reported as ultimately biodegradable. Measured in domestic, adapted activated sludge. (Measured)	OECD SIDS, 2002	Reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Study results: 93%/49 days Test method: 302A: Inherent - Modified SCAS Test Reported as inherently biodegradable. (Measured)	OECD SIDS, 2002	Reported in a guideline study.
	Anaerobic Biodegradation	Primary degradation: 31.1% removal after 3 days in river sediment; 89.7% removal after 40 days (Measured)	OECD SIDS, 2002	Adequate, guideline study.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation	Primary degradation: 43.3% removal after 3 days in river sediment; 86.9% removal after 40 days (Measured)	OECD SIDS, 2002	Adequate, guideline study.
Air	Atmospheric Half-life	12 hours (Estimated)	EPI	
Reactivity	Photolysis	Not a significant fate process (Estimated)	Mill, 2000; Professional judgment	Triphenyl phosphate does not contain functional groups that would be expected to absorb light of wavelengths >290 nm.
		A 0.1 mg/L solution (with acetone) was exposed to a mercury lamp to examine the effect of UV light on the degradation of TPP. High pressure lamp (100W): 100%/20 mins Low pressure lamp (15W): 100%/1 hour (Measured)	EC, 2000	Reported in a secondary source under laboratory conditions.
	Hydrolysis	Half-lives at 25°C: >28 days at pH 5; 19 days at pH 7; 3 days at pH 9 (Measured)	OECD SIDS, 2002	Adequate, guideline study.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		50%/7.5 days Reported at pH 8.2 in river/lake water (Measured)	EC, 2000	Reported in a secondary source.
		50%/1.3 days Reported at pH 9.5 in river/lake water (Measured)	EC, 2000	Reported in a secondary source.
		100%/10 minutes at pH 13 (Measured)	ECHA, 2013	Reported in secondary source. Documentation of study details was not sufficient to assess its reliability.
Environmental Half-Life		In loamy sand, observed half-lives of 37 days (aerobic) and 21 days (anaerobic) (Measured)	OECD SIDS, 2002	Adequate, guideline study.
		75 days (Estimated)	EPI; PBT Profiler	Half-life estimated for the predominant compartment, as determined by EPI and the PBT Profiler methodology.
Bioaccumulation		MODERATE: There is moderate potential for bioaccumulation based on experimental BCF values.		
	Fish BCF	132–364 (Rainbow trout) (Measured)	Mayer et al., 1981	Adequate.
		271 (Rainbow trout) (Measured)	EC, 2000	Reported in a secondary source.
		364 Reported as 132-364 in rainbow trout (Measured)	OECD SIDS, 2002	Insufficient study details to assess the quality of the reported values.
		193 Reported as 84-193 in Medaka (Measured)	EC, 2000	Reported in a secondary source.
		160 Reported as 68-160 in Fathead minnow (Measured)	EC, 2000	Reported in a secondary source.
		144 Medaka (Measured)	OECD SIDS, 2002	Reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		110 Goldfish (Measured)	OECD SIDS, 2002	Reported in a secondary source.
	BAF	73 (Estimated)	EPI	
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		Triphenyl phosphate has been detected in drinking water in samples collected by the USGS. It has also been detected in household dust in the United States (at concentrations of (<173-1,798,100 ng/g), Pakistan, New Zealand, Belgium, Spain and Japan. Triphenyl phosphate has been detected in sediment from Taihu Lake in China at concentrations ranging from 0.41-5.54 µg/kg and in sediment in the U.S. It has also been detected in river water, seawater, rainwater, snow, wastewater effluent, ambient air, and indoor air. (OECD SIDS, 2002; Betts, 2010; vanderVeen and deBoer, 2012; Stiles et al., 2008; Stapleton et al., 2009; Cao et al., 2012; Ali et al., 2012; HSDB, 2013; Salamova et al., 2013)		
Ecological Biomonitoring		Triphenyl phosphate has been detected in fish tissues. It has also been detected in the blubber of bottlenose dolphins collected from the Gulf of Mexico (Campone et al., 2010; Kuehl and Haebler, 1995).		
Human Biomonitoring		Triphenyl phosphate was detected in human milk, adipose tissue and human plasma. This chemical was not included in the NHANES biomonitoring report (CDC, 2013; Shah et al., 2006; ECHA, 2012).		

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Tris(tribromoneopentyl) Phosphate

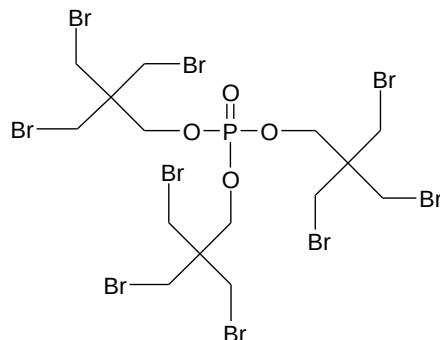
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Tris(tribromoneopentyl) Phosphate	19186-97-1	M	M	L	M	M	H	L	L		L	L	L	L	H	M

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Tris(tribromoneopentyl) Phosphate



CASRN: 19186-97-1

MW: 1,018.5

MF: C₁₅H₂₄Br₉O₄P

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: C(C(CBr)(CBr)CBr)OP(=O)(OCC(CBr)(CBr)CBr)OCC(CBr)(CBr)CBr

Synonyms: 1-Propanol, 3-bromo-2,2-bis(bromomethyl)-, 1,1',1"-phosphate; 1-Propanol, 3-bromo-2,2-bis(bromomethyl)-, phosphate (3:1); 3-Bromo-2,2-bis(bromomethyl)propan-1-ol, phosphate (3:1); Tris[3-bromo-2,2-bis(bromomethyl)propyl]phosphate; Tris(tribromoneopentyl) phosphate; Tris[2,2-bis(bromomethyl)-3-bromopropyl] phosphate; Tris[3-bromo-2,2-bis(bromomethyl)propyl] phosphate; CR-900; Flame Cut 175; Flame Cut 175R; TPB 3070; FR 370; FR 372; Kronitex PB 370; Reoflam FR 370

Chemical Considerations: This is a discrete organic chemical with a MW slightly greater than 1,000. EPI v 4.0 was used to estimate physical/chemical and environmental fate values due to an absence of experimental data. To provide robust estimates, physical-chemical property data from experimental studies were incorporated into the estimation software.

Polymeric: No

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: None

Analog: No analog

Endpoint(s) using analog values: Not applicable

Analog Structure: Not applicable

Structural Alerts: None

Risk Phrases: Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).

Hazard and Risk Assessments: None identified.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	183 (Measured)	Fisk et al., 2003	Adequate. Consistent values, which span a relatively narrow range, have been reported in secondary sources.
	182-184 (Measured)	NICNAS, 2001	
	180-182 (Measured)	Harju et al., 2009	
Boiling Point (°C)	>300 (Estimated)	EPI; EPA, 1999	Cutoff value for high boiling compounds according to High Production Volume assessment guidance.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	EPI; EPA, 1999	Cutoff value for nonvolatile compounds according to HPV assessment guidance.
Water Solubility (mg/L)	0.9 (Measured)	NICNAS, 2001; Fisk et al., 2003	Adequate.
Log K_{ow}	8.1 (Estimated)	EPI	This compound may lie just outside of the MW domain for the estimation method, although the results are consistent with a high MW material with limited water solubility.
	3.7 (Measured)	NICNAS, 2001; Fisk et al., 2003	Value inconsistent with measured water solubility. Reported in a secondary source; study details and test conditions were not provided.
Flammability (Flash Point)	388.8°C (Measured)	ChemNet, 2011	Adequate.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH	Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pK _a		Not applicable	Professional judgment	Does not contain functional groups that are expected to ionize under environmental conditions.
HUMAN HEALTH EFFECTS				
Toxicokinetics		Tris(tribromoneopentyl) phosphate is poorly absorbed in rats following oral (gavage) exposure. In addition, as a neat material, this substance is estimated to not be absorbed through the skin and to have poor skin absorption when in solution. Tris(tribromoneopentyl) phosphate is expected to have poor absorption via the lungs and gastrointestinal (GI) tract. This material is a potential alkylating and crosslinking agent.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	Not absorbed through the skin as a neat material and poor absorption through skin when in solution; poor absorption through the lung and GI tract. (Estimated by analogy)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
		Rats administered test substance via oral gavage; 1% of administered dose was absorbed, with the proportion of radioactive material excreted as unchanged test material in urine or feces within 48 hours of dosing.	Submitted confidential study	Reported in a submitted confidential study; Study conducted according to good laboratory practice (GLP).
		This material is a potential alkylating and crosslinking agent (Estimated)	Professional judgment	Estimated based on professional judgment.
Acute Mammalian Toxicity		MODERATE: Estimated to have potential for acute toxicity based on alkylation and expert judgment; no data located.		
Acute Lethality	Oral	Potential for acute toxicity based on a consideration of the mechanistic potential for alkylation (Estimated)	Expert judgment	Estimated based on expert judgment.
	Dermal			
	Inhalation			

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Carcinogenicity		MODERATE: Estimated to have moderate potential for carcinogenicity based on a mechanistic consideration of the potential for alkylation and crosslinking using professional judgment.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	There is potential for carcinogenicity based on a consideration of the mechanistic potential for alkylation and crosslinking. (Estimated by analogy)	Professional judgment	Estimated based on professional judgment.
	Combined Chronic Toxicity/ Carcinogenicity			
Genotoxicity		LOW: Tris(tribromoneopentyl) phosphate was not mutagenic in bacteria or mouse lymphoma cells and did not cause chromosomal aberrations in Chinese hamster ovary (CHO) cells <i>in vitro</i> .		
	Gene Mutation <i>in vitro</i>	There is potential for mutagenicity based on the potential for alkylation and crosslinking. (Estimated by analogy)	Professional judgment	Estimated based on professional judgment.
		Negative, <i>Salmonella typhimurium</i> strains TA98, TA100, TA1535, TA1537, TA1538 with and without metabolic activation.	Submitted confidential study	Reported in a submitted confidential study; Study conducted according to GLP.
		Negative, mouse lymphoma L5178Y cells, with and without metabolic activation.	Submitted confidential study	Reported in a submitted confidential study.
	Gene Mutation <i>in vivo</i>			
	Chromosomal Aberrations <i>in vitro</i>	Negative, CHO cells, with and without metabolic activation. Equivocal results in cytogenic assay for numerical aberrations.	Submitted confidential study	Reported in a submitted confidential study.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		MODERATE: Estimated to have potential for reproductive effects based on alkylation and expert judgment; no data located.		
	Reproduction/ Developmental Toxicity Screen	Potential for reproductive toxicity based on a consideration of the mechanistic potential for alkylation (Estimated)	Expert judgment	Estimated based on expert judgment.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		MODERATE: For developmental toxicity a NOAEL of 300 mg/kg-day and a LOAEL of 1,000 mg/kg-day (for slightly reduced fetal weight and marginally increased placental weight) were reported for rats orally exposed on gestation days (GDs) 1-19 which aligns with a low hazard designation. However, there is moderate potential for neurodevelopmental effects from exposure to tris(tribromoneopentyl) phosphate based on presence of alkylating groups and potential for cholinesterase inhibition. There were no studies located that were specifically designed to evaluate the neurodevelopmental endpoint.		
	Reproduction/ Developmental Toxicity Screen	There is potential for developmental and neurodevelopmental effects based on a mechanistic consideration of the potential for alkylation and crosslinking, and cholinesterase inhibition. (Estimated by analogy)	Professional judgment	Estimated based on cholinesterase inhibition by analogy to tris (1,3-dichloro-2-propyl phosphate.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Prenatal Development	Pregnant rats; oral gavage; GDs1-19; 100, 300 or 1,000 mg/kg-day test substance. Maternal: No deaths. No significant clinical signs or toxicity or changes in bodyweight or food consumption. No adverse effects on mean implantation count, incidence of pre-or post-implantation losses or numbers of live young. Fetal: Slightly reduced fetal weight and marginally increased placental weight (1,000 mg/kg); No skeletal or visceral anomalies. NOAEL = 300 mg/kg-day for fetuses based on slight reduction of fetal growth LOAEL = 1,000 mg/kg-day (slightly reduced fetal weight; marginally increased placental weight)	Submitted confidential study	Reported in a submitted confidential study; Study conducted in accordance with GLP.
	Postnatal Development			No data located.
Neurotoxicity		HIGH: Estimated to have high potential for neurotoxicity based on the potential for the neopentyl alcohol groups acting as leaving groups, based on professional judgment.		
	Neurotoxicity Screening Battery (Adult)	There is a potential for neurotoxicity using a mechanistic analysis based on the formation of neopentyl alcohol groups due to their ability to act as good leaving groups. (Estimated by analogy)	Professional judgment	Estimated based on professional judgment.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Repeated Dose Effects	LOW: There were no treatment-related effects in rats following 28- or 90-day exposures at oral doses up to 20,000 ppm (1,358 and 1,685 mg/kg/day for males and females, respectively in the 90 day dietary study in rats). There is uncertain potential for liver effects based on the bromo substituents of tris(tribromoneopentyl) phosphate, based on professional judgment.		
	There is an uncertain potential for liver effects based on a mechanistic consideration of the reactions of the bromo substituents of this chemical. (Estimated by analogy)	Professional judgment	Estimated based on professional judgment.
	28-day study, rats, oral gavage, 0, 400, 8,000, 20,000 ppm test material. No deaths. No treatment-related clinical signs of toxicity or significant changes in body weight, overall body weight gains or food consumption. No changes in hematological or clinical chemistry parameters or in organ weights. No compound-related macroscopic or microscopic effects. NOAEL = 20,000 ppm (highest dose tested)	Submitted confidential study	Reported in a submitted confidential study; Conducted in accordance with GLP.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		90-day dietary study in rats; 0, 2,000, 10,000, or 20,000 ppm test material. No treatment-related deaths or clinical signs of toxicity. No treatment-related changes in body weight, ophthalmic lesions or urinalysis/clinical chemistry/hematological parameters. No treatment-related findings during necropsy or changes in organ weight. No histopathological changes. NOAEL = 20,000 ppm (1,358 and 1,685 mg/kg/day for males and females, respectively); highest dose tested.	Submitted confidential study	Reported in a submitted confidential study; Conducted in accordance with GLP.
Skin Sensitization		LOW: Not a skin sensitizer in guinea pigs. There is some potential for skin sensitization based on a mechanistic consideration of the potential for alkylation and crosslinking, based on professional judgment.		
	Skin Sensitization	There is potential for skin sensitization based on a mechanistic consideration of the potential for alkylation and crosslinking. (Estimated by analogy)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
		Not sensitizing, guinea pigs	Submitted confidential study	Reported in a submitted confidential study.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Estimated to have low potential for eye irritation based on expert judgment.		
	Eye Irritation	Low potential for eye irritation. (Estimated)	Expert judgment	Estimated based on expert judgment.
Dermal Irritation		LOW: Estimated to have low potential for dermal irritation based on expert judgment.		
	Dermal Irritation	Low potential for skin irritation. (Estimated)	Expert judgment	Estimated based on expert judgment.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Endocrine Activity		No data located.		
				No data located.
Immunotoxicity		No data located.		
	Immune System Effects			No data located.
ECOTOXICITY				
ECOSAR Class				
Acute Toxicity		LOW: Tris(tribromopentyl) phosphate’s large MW, limited bioavailability and low water solubility suggest there will be no effects at saturation (NES). The estimated log K _{ow} of 8.1 also is indicative of NES based on ECOSAR cutoff values.		
Fish LC ₅₀		Fish 96-hour LC ₅₀ >10 mg/L (test concentration exceeded water solubility)	Fisk et al., 2003	Inadequate; details are missing as this is a review on various chemicals. In addition, the LC ₅₀ is greater than the highest test concentration.
		Fish 96-hour LC ₅₀ = 0.006 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The large MW, limited bioavailability and low water solubility suggest there will be NES; the log K _{ow} of 8.1 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Daphnia 48-hour LC ₅₀ = 0.007 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The large MW, limited bioavailability and low water solubility suggest there will be NES; the log K _{ow} of 8.1 for this chemical exceeds the SAR limitation for log K _{ow} of 5.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Green Algae EC₅₀	Green algae 96-hour EC ₅₀ = 0.037 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The large MW, limited bioavailability and low water solubility suggest there will be NES; the log K _{ow} of 8.1 for this chemical exceeds the SAR limitation for log K _{ow} of 6.4. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Chronic Aquatic Toxicity	LOW: The large MW, limited bioavailability, and low water solubility suggest there will be NES. The estimated log K_{ow} of 8.1 is indicative of NES based on ECOSAR cutoff values.		

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Fish ChV	Fish ChV = 0.000495 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The large MW, limited bioavailability and low water solubility suggest there will be NES; the log K _{ow} of 8.1 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
Daphnid ChV	Daphnid ChV = 0.00192 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The large MW, limited bioavailability and low water solubility suggest there will be NES; the log K _{ow} of 8.1 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Green Algae ChV		Green algae ChV = 0.040 mg/L (Estimated) ECOSAR: Neutral organics	ECOSAR version 1.11	NES: The large MW, limited bioavailability and low water solubility suggest there will be NES; the log K _{ow} of 8.1 for this chemical exceeds the SAR limitation for log K _{ow} of 8.0. ECOSAR also provided results for the Esters, and Esters (phosphate) classes; however, professional judgment indicates that this compound does not lie within the domain of the ECOSAR model.
ENVIRONMENTAL FATE				
Transport		Evaluation of tris(tribromoneopentyl) phosphate transport is based entirely on estimations from quantitative structure activity relationships. Tris(tribromoneopentyl) phosphate is expected to have low mobility in soil based on its expected strong absorption to soil. If released to the atmosphere, tris(tribromoneopentyl) phosphate is likely to exist solely as particulate. As a particulate, atmospheric oxidation is not expected to be a significant route of environmental removal. Based on the Henry's Law constant, volatilization from water or moist soil is not expected to occur at an appreciable rate. Level III fugacity models indicate that tris(tribromoneopentyl) phosphate will partition predominantly to the soil.		
	Henry's Law Constant (atm·m ³ /mole)	<10 ⁻⁸ (Estimated)	EPI; Professional judgment	Cutoff value for nonvolatile compounds.
	Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	EPI; EPA, 1999	Cutoff value for nonmobile compounds according to HPV assessment guidance.
	Level III Fugacity Model	Air: <1% (Estimated) Water = 1% Soil = 64% Sediment = 35%	EPI	

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Persistence		HIGH: This substance has a MW slightly >1,000. It is expected to have negligible water solubility and poor bioavailability to microorganisms indicating that biodegradation is not expected to be an important removal process in the environment. Estimated hydrolysis half-lives of approximately 10 years indicate that this will not be an important environmental removal process. Tris(tribromoneopentyl) phosphate does not contain functional groups that would be expected to absorb light at environmentally significant wavelengths. As a result, tris(tribromoneopentyl) phosphate is expected to have high potential for environmental persistence.		
Water	Aerobic Biodegradation	Weeks-months (primary survey model); Recalcitrant (ultimate survey model) (Estimated)	EPI	Although this compound may lie just outside of the MW domain for the estimation method, the results are consistent with a high MW material that is not expected to be readily assimilated.
	Volatilization Half-life for Model River	>1 year (Estimated)	EPI	Based on the magnitude of the estimated Henry's Law Constant.
	Volatilization Half-life for Model Lake	>1 year (Estimated)	EPI	Based on the magnitude of the estimated Henry's Law Constant.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation	Probable (Anaerobic-methanogenic biodegradation probability model) (Estimated)	EPI; Professional judgment	The model predictions are being driven by reduction of the bromine substituent. Under environmental conditions, the rate for anaerobic degradation will likely be attenuated due to the low water solubility and limited bioavailability of this material.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	Not a significant fate process (Estimated)	Professional judgment	This chemical is expected to exist in the particulate phase in the atmosphere.

Tris(tribromoneopentyl) Phosphate CASRN 19186-97-1				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reactivity	Photolysis			No data located.
	Hydrolysis	pH 7 = 9.9 years (Estimated) pH 8 = 9.9 years	EPI	
	Pyrolysis			No data located.
Environmental Half-life		>180 days (Estimated)	Professional judgment	The substance has a MW slightly >1,000 and is not anticipated to be assimilated by microorganisms. Therefore, biodegradation is not expected to be an important removal process. It is also not expected to be readily removed by other degradative processes under environmental conditions because of limited water solubility and lack of reactive functional groups.
Bioaccumulation		MODERATE: The estimated BCF is >100 and <1,000.		
	Fish BCF	609 (Estimated)	EPI	
	BAF	8.8 (Estimated)	EPI	
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

CDC (Centers for Disease Control and Prevention). *Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables*. Department of Health and Human Services. **2011**. http://www.cdc.gov/exposurereport/pdf/Updated_Tables.pdf as of May 10, 2011.

ChemNet. ChemNet.com Physical and chemical property page for 19186-97-1 2,2-Bis-(bromomethyl)-3-bromo-1-propanol phosphate. [http://www.chemnet.com/cas/en/19186-97-1/Tris\(tribromoneopentyl\)phosphate.html](http://www.chemnet.com/cas/en/19186-97-1/Tris(tribromoneopentyl)phosphate.html) (accessed January 19, **2011**).

[HPV Assessment Guidance] EPA (U.S. Environmental Protection Agency). High Production Volume (HPV) Challenge. Determining the Adequacy of Existing Data. U.S. Environmental Protection Agency: Washington D.C. **1999**. <http://www.epa.gov/hpv/pubs/general/datadfin.htm>

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EPI (EPIWIN/EPISUITE) Estimation Program Interface for Windows, Version 4.0. U.S. Environmental Protection Agency: Washington D.C. <http://www.epa.gov/opptintr/exposure/>.

ESIS (European chemical Substances Information System) Classification, labeling and packaging of dangerous substances annex VI to regulation (EC) No 1272/2008 [Online] available at: <http://esis.jrc.ec.europa.eu/clp-ghs> as of May 10, **2011**.

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Harju, M.; Heimstad, E.; Herzke, D.; et al. Current state of knowledge and monitoring requirements - Emerging "new" brominated flame retardants in flame retarded products and the environment (TA-2462/2008). Norwegian Pollution Control Authority, Oslo, Norway. **2009**.

NICNAS (National Industrial Chemicals Notification and Assessment Scheme). Polybrominated flame retardants (PBFRs) priority existing chemical assessment Report No. 20 National Occupational Health and Safety Commission, Australia. **2001**.

Tris(tribromophenoxy) Triazine

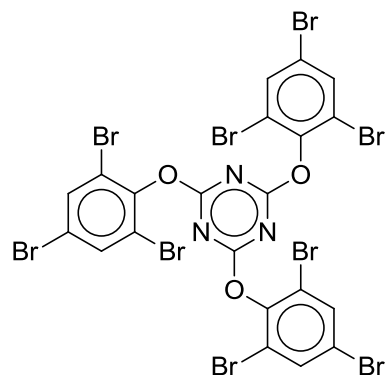
Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Tris(tribromophenoxy) Triazine	25713-60-4	L	L	L	L	L	L	L	L		L	VL	L	L	VH	H

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Tris(tribromophenoxy) Triazine



CASRN: 25713-60-4

MW: 1,067.43

MF: C₂₁H₆Br₉N₃O₃

Physical Forms:

Neat: Solid

Use: Flame retardant

SMILES: c1(Br)c(Oc2nc(Oc3c(Br)cc(Br)cc3Br)nc(Oc3c(Br)cc(Br)cc3Br)n2)c(Br)cc(Br)c1

Synonyms: 1,3,5-Triazine, 2,4,6-tris(2,4,6-tribromophenoxy)-; Tris(tribromophenoxy) triazine; FR 245; Tris(2,4,6-tribromophenoxy)-s-triazine; Tris(tribromophenoxy)-s-triazine; Tris(tribromophenyl) cyanurate

Chemical Considerations: This is a discrete organic chemical with a MW slightly greater than 1,000. EPI v 4.0 was used to estimate physical/chemical and environmental fate values due to an absence of experimental data.

Polymeric: No

Oligomers: Not applicable

Metabolites, Degradates and Transformation Products: Tribromophenol (NICNAS, 2006)

Analog: No analog

Endpoint(s) using analog values: Not applicable

Analog Structure: Not applicable

Structural Alerts: Reproductive toxicity, triazines (EPA, 2011)

Risk Phrases: Not classified by Annex I Directive 67/548/European Economic Community (EEC) & IUCLID (Pakalin et al., 2007).

Hazard and Risk Assessments: None identified.

Tris(tribromophenoxy) Triazine CASRN 25713-60-4

PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	228-229 (Measured) EC Directive 92/69/EEC A.1	NICNAS, 2006	Adequate; reported in a secondary source. Melting started at 216-218°C, likely due to impurities in test substance.
Boiling Point (°C)	Decomposition at >275 (Measured) EC Directive 92/69/EEC A.1 using 99.5% pure test substance	NICNAS, 2006	Adequate; reported in a secondary source.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	EPI; EPA, 1999	Cutoff value for nonvolatile compounds according to HPV assessment guidance.
Water Solubility (mg/L)	<10 ⁻³ at 20°C (Measured) Organisation of Economic Cooperation and Development (OECD) TG 105, Good laboratory practice compliant	NICNAS, 2006	Adequate; reported in a secondary source. Reported value also corresponds to the cutoff value for nonsoluble compounds according to High Production Volume assessment guidance.
Log K_{ow}	>10 (Estimated)	EPI; EPA, 1999	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance. Cutoff value used according to HPV assessment guidance.
Flammability (Flash Point)	Nonflammable (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Explosivity	Not expected to form explosive mixtures with air (Estimated)	Professional judgment	No experimental data located; based on its use as a flame retardant.
Pyrolysis			No data located.
pH			No data located.

Tris(tribromophenoxy) Triazine CASRN 25713-60-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
pK _a				No data located; the high MW precludes the use of available estimation methods.
HUMAN HEALTH EFFECTS				
Toxicokinetics		Tris(tribromophenoxy) triazine has a MW >1,000 and limited water solubility. There is no absorption expected for any route of exposure for this compound and is not expected to be absorbed, distributed or metabolized in the body. The lack of absorption is expected to result in low hazard potential.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No absorption expected for any route of exposure (Estimated)	Professional judgment	Estimated based on professional judgment.
Acute Mammalian Toxicity		LOW: Tris(tribromophenoxy) triazine has a MW >1,000 and limited water solubility. It is expected to have limited bioavailability and therefore has low potential for acute mammalian toxicity. In addition, oral and dermal LD ₅₀ values >2,000 indicate a low level of toxicity.		
Acute Lethality	Oral	Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.
		Rat oral LD ₅₀ >2,000 mg/kg	NICNAS, 2006	Reported in a secondary source.
	Dermal	Rat dermal LD ₅₀ >2,000 mg/kg	NICNAS, 2006	Reported in a secondary source.
	Inhalation			No data located.
Carcinogenicity		LOW: Tris(tribromophenoxy) triazine is expected to have limited bioavailability. It is estimated to have low potential for carcinogenicity based on professional judgment.		
	OncoLogic Results	Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.
	Carcinogenicity (Rat and Mouse)			
	Combined Chronic Toxicity/ Carcinogenicity			

Tris(tribromophenoxy) Triazine CASRN 25713-60-4				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Genotoxicity		LOW: Tris(tribromophenoxy) triazine was not mutagenic in <i>Salmonella typhimurium</i> and did not induce chromosome aberrations in human peripheral lymphocytes or L5178Y mouse lymphoma cells. Tris(tribromophenoxy) triazine is expected to have limited bioavailability and therefore has low potential for genotoxicity.		
	Gene Mutation <i>in vitro</i>	Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.
		Negative, Ames assay in <i>Salmonella typhimurium</i> strains TA1535, TA1537, TA98, TA100, with and without activation.	NICNAS, 2006	Reported in a secondary source.
	Gene Mutation <i>in vivo</i>			No data located.
	Chromosomal Aberrations <i>in vitro</i>	Negative, Mammalian Chromosome Aberration Test in cultured human peripheral lymphocytes, with and without activation. Precipitation was noted at the highest concentration tested.	NICNAS, 2006	Reported in a secondary source.
		Negative, Mammalian Cell Gene Mutation Test in L5178Y mouse lymphoma cells with and without activation. Precipitation was noted at the highest concentration tested.	NICNAS, 2006	Reported in a secondary source.
	Chromosomal Aberrations <i>in vivo</i>			No data located.
	DNA Damage and Repair			No data located.
	Other (Mitotic Gene Conversion)			No data located.
Reproductive Effects		LOW: Tris(tribromophenoxy) triazine is expected to have limited bioavailability. It is estimated to have low potential for reproductive effects based on professional judgment.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.

Tris(tribromophenoxy) Triazine CASRN 25713-60-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Reproduction and Fertility Effects			
Developmental Effects		LOW: Tris(tribromophenoxy) triazine is expected to have limited bioavailability. It is estimated to have low potential for developmental effects based on professional judgment.		
	Reproduction/ Developmental Toxicity Screen	Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			
	Prenatal Development			
	Postnatal Development			
Neurotoxicity		LOW: Tris(tribromophenoxy) triazine is expected to have limited bioavailability. It is estimated to have low potential for neurotoxicity based on professional judgment.		
	Neurotoxicity Screening Battery (Adult)	Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.
Repeated Dose Effects		LOW: Tris(tribromophenoxy) triazine is expected to have limited bioavailability. It is estimated to have low potential for repeated dose effects based on professional judgment. Results from a 28-day repeated dose study are consistent with this low hazard designation.		
		Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.

Tris(tribromophenoxy) Triazine CASRN 25713-60-4				
PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		In a 28-day repeated dose study, rats (6/sex) were orally exposed to 0, 10, 50, 250, or 1,000 mg/kg bw-day. There was neither mortality nor treatment-related clinical signs of toxicity. There was a decreased reticulocyte count and relative adrenal weight in females and increased relative liver weight and decreased relative kidney weight in males; however, these effects were not considered dose- or treatment-related. NOAEL = 1,000 mg/kg bw/day (highest dose tested)	NICNAS, 2006	Reported in a secondary source.
Skin Sensitization		LOW: Tris(tribromophenoxy) triazine is not a skin sensitizer in guinea pigs.		
	Skin Sensitization	Negative results in a skin sensitization maximization test in guinea pigs (0–6% response rate).	NICNAS, 2006	Reported in a secondary source.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Tris(tribromophenoxy) triazine is a slight eye irritant in rabbits.		
	Eye Irritation	Slightly irritating to rabbit eyes	NICNAS, 2006	Reported in a secondary source.
Dermal Irritation		VERY LOW: Tris(tribromophenoxy) triazine is not a skin irritant in rabbits.		
	Dermal Irritation	Non-irritating to rabbit skin	NICNAS, 2006	Reported in a secondary source.
Endocrine Activity		Tris(tribromophenoxy) triazine is expected to have limited bioavailability based on its MW. It is estimated to have low potential for endocrine activity based on professional judgment. No data located.		
		Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.

Tris(tribromophenoxy) Triazine CASRN 25713-60-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Immunotoxicity		No data located. Tris(tribromophenoxy) triazine is expected to have limited bioavailability based on its MW that is slightly above 1,000 daltons. It is estimated to have low potential for immunotoxicity based on professional judgment with some uncertainty because the MW of this compound is near the cutoff of 1,000 daltons.		
	Immune System Effects	Limited bioavailability expected (Estimated)	Professional judgment; EPA, 1999	Based on HPV discrete organic chemicals assessment guidance.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		LOW: Tris(tribromophenoxy) triazine is expected to display no effects at saturation (NES) because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.		
Fish LC₅₀		NES	Professional judgment	The MW >1,000, limited bioavailability and low water solubility suggest there will be NES.
Daphnid LC₅₀		NES	Professional judgment	The MW >1,000, limited bioavailability and low water solubility suggest there will be NES.
Green Algae EC₅₀		NES	Professional judgment	The MW >1,000, limited bioavailability and low water solubility suggest there will be NES.
Chronic Aquatic Toxicity		LOW: Tris (tribromophenoxy) triazine is expected to display NES because the amount dissolved in water is not anticipated to reach a concentration at which adverse effects may be expressed.		
Fish ChV		NES	Professional judgment	The MW >1,000, limited bioavailability and low water solubility suggest there will be NES.
Daphnid ChV		NES	Professional judgment	The MW >1,000, limited bioavailability and low water solubility suggest there will be NES.

Tris(tribromophenoxy) Triazine CASRN 25713-60-4

Tris(tribromophenoxy) Triazine CASRN 25713-60-4			
PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
Green Algae ChV	NES	Professional judgment	The MW >1,000, limited bioavailability and low water solubility suggest there will be NES.
ENVIRONMENTAL FATE			
Transport	The transport assessment for tris(tribromophenoxy) triazine is based almost entirely on behavior anticipated for high MW (>1,000), water insoluble, nonvolatile materials. Leaching of tris(tribromophenoxy) triazine through soil to groundwater is not expected to be an important transport mechanism. Estimated volatilization half-lives indicate that it will be nonvolatile from surface water. Volatilization from dry surface is also not expected based on its vapor pressure. In the atmosphere, this compound is expected to exist solely in the particulate phase, based on its estimated vapor pressure. Particulates may be removed from air by wet or dry deposition.		
Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	EPI; Professional judgment	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance. Cutoff value used for nonvolatile compounds.
Sediment/Soil Adsorption/Desorption Coefficient – K _{oc}	>30,000 (Estimated)	EPI; EPA, 1999	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance. Cutoff value for non mobile compounds according to HPV assessment guidance.
Level III Fugacity Model	Air: <1% (Estimated) Water = 4.2% Soil = 93% Sediment = 2.8%	EPI	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance.

Tris(tribromophenoxy) Triazine CASRN 25713-60-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Persistence		VERY HIGH: Biodegradation is not expected to be a major removal process based on experimental data. No biodegradation occurred in a 28-day ready biodegradation test. In a guideline inherent biodegradation test, only 4% of the test substance was removed in 72 days. Therefore, biodegradation is not expected to be a major removal process. Volatilization, atmospheric photooxidation, and hydrolysis are also not expected to occur. Therefore, tris(tribromophenoxy) triazine is expected to be highly persistent in the environment.		
Water	Aerobic Biodegradation	Not readily biodegradable after 28 days; no degradation measured by biochemical oxygen demand using microorganisms obtained from activated sludge, 6% measured by high performance liquid chromatography (Measured)	NICNAS, 2006	Adequate; value reported in a secondary source.
		Not inherently biodegradable after 72 days; 4% degradation according to OECD 302D (Measured)	NICNAS, 2006	Adequate; value reported in a secondary source.
		Recalcitrant (Estimated)	EPI; Professional judgment	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance.
		Not probable (Anaerobic-methanogenic biodegradation probability model) (Estimated)	EPI; Professional judgment	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance.
	Volatilization Half-life for Model River	>1 year (Estimated)	EPI; Professional judgment	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance.

Tris(tribromophenoxy) Triazine CASRN 25713-60-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Volatilization Half-life for Model Lake	>1 year (Estimated)	EPI; Professional judgment	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	Not a significant fate process (Estimated)	Professional judgment	This chemical is expected to exist in the particulate phase in the atmosphere.
Reactivity	Photolysis			No data located.
	Hydrolysis	Not a significant fate process (Estimated)	Wolfe and Jeffers, 2000; Professional judgment	The substance does not contain functional groups that would be expected to hydrolyze and has negligible water solubility.
Environmental Half-life		>180 days (Estimated)	EPI; Professional judgment	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance.
Bioaccumulation		HIGH: The estimated BAF for this chemical is >5,000. Although measured BCF values were located, estimated BAF values are incorporated for a conservative approach. The BAF estimate is consistent with the potential for bioaccumulation that is anticipated for high MW chemicals with a high degree of bromination.		

Tris(tribromophenoxy) Triazine CASRN 25713-60-4

PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Fish BCF	<0.8 to 9; <8 to 18 Carp (Measured) Using continuous flow-through test	NICNAS, 2006	Results are consistent with chemicals with low water solubility and high MW, suggesting limited transport through gills.
	BAF	8,800 (Estimated)	EPI	Although this material may be outside the MW domain for the estimation model, the resulting value is consistent with that anticipated for a highly brominated, high MW substance. Assessment criteria indicate estimated BAF may be used in preference to measured BCF values.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

CDC (Centers for Disease Control and Prevention). *Fourth national report on human exposure to environmental chemicals, updated tables*. Department of Health and Human Services. **2011**. http://www.cdc.gov/exposurereport/pdf/Updated_Tables.pdf (accessed on May 10, 2011).

U.S. EPA (Environmental Protection Agency). High Production Volume (HPV) Challenge. Determining the Adequacy of Existing Data. U.S. Environmental Protection Agency: Washington D.C. 1999. <http://www.epa.gov/hpv/pubs/general/datadfin.htm>

EPA Sustainable Futures. *Using NonCancer Screening within the SF Initiative*. U.S. Environmental Protection Agency: Washington D.C. **2011**. <http://www.epa.gov/opptintr/sf/pubs/noncan-screen.htm#systemic> (accessed on February 09, 2011).

EPI (*EPIWIN/EPISUITE*) *Estimation Program Interface for Windows*, Version 4.0. U.S. Environmental Protection Agency: Washington D.C. <http://www.epa.gov/opptintr/exposure/>.

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Wolfe, N.; Jeffers, P. (2000) Hydrolysis. In Boethling, R.; Mackay, D., *Handbook of Property Estimation Methods for Chemicals*, Environmental Health Sciences (311-334). Boca Raton: Lewis Publishers.

Zinc Borate

Screening Level Hazard Summary

This table only contains information regarding the inherent hazards of flame retardant chemicals. Evaluation of risk considers both the hazard and exposure associated with the substance including combustion and degradation by-products. The caveats listed in the legend and footnote sections must be taken into account when interpreting the hazard information in the table below.

VL = Very Low hazard L = Low hazard M = Moderate hazard H = High hazard VH = Very High hazard — Endpoints in colored text (VL, L, M, H, and VH) were assigned based on empirical data. Endpoints in black italics (VL, L, M, H, and VH) were assigned using values from estimation software and professional judgment. ^R Recalcitrant: substance is or contains inorganics, such as metal ions or elemental oxides, that are expected to be found in the environment >60 days after release.																
Chemical	CASRN	Human Health Effects											Aquatic Toxicity**		Environmental Fate	
		Acute Toxicity	Carcinogenicity	Genotoxicity	Reproductive	Developmental	Neurological	Repeated Dose	Skin Sensitization	Respiratory Sensitization	Eye Irritation	Dermal Irritation	Acute	Chronic	Persistence	Bioaccumulation
Zinc Borate	1332-07-6	L	L	H	M	M	H	L	L		L	L	H	H	H ^R	L

**Aquatic toxicity: EPA/DfE criteria are based in large part upon water column exposures which may not be adequate for poorly soluble substances such as many flame retardants that may partition to sediment and particulates.

Zn^{2+} $\begin{array}{c} \text{HO}-\text{B}-\text{O}^- \\ \\ \text{OH} \end{array}$	CASRN: 1332-07-6, 138265-88-0
	MW: 125
	MF: ZnBO_3H (Empirical)
	Physical Forms: Neat: Solid Use: Flame retardant
SMILES: Not applicable	
Synonyms: Boric acid, zinc salt; Boron zinc hydroxide oxide; Alcanex FR 100; Alcanex FRC 600; Bonrex FC; Borax 2335; Borogard ZB; Climax; ZB 467; 128859; FRC 600; Firebrake 415; Firebrake 500; Firebrake ZB; Flamtard Z 10; JS 9502; SZB 2335; Storshield ZB2335; XPI 187; ZB 112; ZB 113; ZB 223; ZB 237; ZB 325; ZB 467 Lite; ZB-Shield; ZN 100; ZSB 2335; ZT; Zinc borate	
Chemical Considerations: This alternative is an inorganic compound. Zinc borates have the general formula $x\text{ZnO} \cdot y\text{B}_2\text{O}_3 \cdot z\text{H}_2\text{O}$. Zinc borate hydrate analogs may have differing and possibly complex ratios for the water of hydration. In the absence of experimental data, professional judgment using chemical class and structural considerations were used to complete this hazard profile.	
Polymeric: No Oligomers: Not applicable	
Metabolites, Degradates and Transformation Products: Zinc (23713-49-7), borate (39201-27-9), zinc oxide (1314-13-2), zinc hydroxide, boric acid (10043-35-3; 11113-50-1)	
Analogs: Zinc borate hydrate analogs include CASRNs 12447-61-9, 12513-27-8, 27043-84-1, 12280-01-2, 12429-73-1, 12536-65-1, 147749-62-2 (Briggs, 2004; Smith, 2002; Lide, 2008; Touval, 2000; Goodwin, 2006); analog data from other confidential compounds was also used. Endpoint(s) using analog values: Not applicable	Analog Structure: $\left[\text{Zn}^{2+} \right]_x$ $\left[\begin{array}{c} \text{HO}-\text{B}-\text{O}^- \\ \\ \text{OH} \end{array} \right]_y$ $\left[\text{H}-\text{O}-\text{H} \right]_z$
Structural Alerts: Boron containing compounds, developmental toxicity (EPA, 2011a).	
Risk Phrases: R50/53 – Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment. Zinc borate’s dissolution produces soluble zinc ions (U.S. Borax, Inc., 2002). Not classified by Annex VI Regulation (EC) No 1272/2008 (ESIS, 2011).	
Hazard and Risk Assessments: Risk assessment completed for zinc borate by the National Academy of Sciences (NAS, 2000); Pesticide Registration Review completed by EPA (2011b).	

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
PHYSICAL/CHEMICAL PROPERTIES			
Melting Point (°C)	980 (for 12513-27-8 and 138265-88-0) (Estimated by analogy)	Lewis, 1993; NAS, 2000; Gowda, 2007; Lide, 2008	The values reported for the zinc borate and its hydrates are consistent with that expected for these inorganic salts, which are characterized by high melting points. At elevated temperatures, the hydrated materials may lose their waters of hydration.
	Phase change at 650 (Measured)	U.S. Borax Inc., 2002	
	>550 (for 12447-61-9) (Estimated by analogy)	EPA, 1991 (as described in Maine DEP, 2007)	
Boiling Point (°C)	>500, Decomposes (Estimated)	Professional judgment	Adequate; decomposition occurs upon melting as described in located sources above. This is anticipated to occur at or above the melting point.
Vapor Pressure (mm Hg)	<10 ⁻⁸ (Estimated)	Professional judgment; EPA, 1999	Cutoff value for nonvolatile materials according to HPV assessment guidance; expected for an inorganic salt.
	Negligible (Measured)	HDP, 2004	Qualitative, nonspecific value.
Water Solubility	<0.28% at 25°C (Measured)	Clayton and Clayton, 1994; HDP, 2004; U.S. Borax Inc., 2002	The values reported for the zinc borate hydrates indicate that its dissolution is pH dependent and includes the pH range 5-7 that is typically found in the environment.
	0.1% at pH 5 and 7 and 23°C 0.03% at pH 9 and 23°C (for 12447-61-9) (Estimated by analogy)	Lindsay, 1991	
	Zinc borate is slightly soluble in water. At low pH, zinc borate can dissociate to zinc and borate ions (for 12447-61-9) (Estimated by analogy)	Sanders, 2007	Indicates the potential for liberation of zinc ions under acid conditions such as those found in the stomach.
Log K_{ow}			No data located. Compound is not amenable to available estimation techniques.
Flammability (Flash Point)	Nonflammable (Measured)	Sax and Lewis, 1987	Adequate.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Explosivity		Not explosive (Measured)	U.S. Borax, Inc., 2002	Adequate.
Pyrolysis		Not applicable (Estimated)	Professional judgment	Inorganic compounds do not undergo pyrolysis.
pH		7.6 (for 12447-61-9) (Estimated by analogy) In a 1% suspension of product to distilled water by mass concentration (w:w).	Gowda, 2007	Adequate; indicates that this substance is a weak base in solution.
pK _a				No data located; inorganic compounds are outside the estimation domain of SPARC.
HUMAN HEALTH EFFECTS				
Toxicokinetics		Zinc borate is estimated to not be absorbed through skin. Absorption is expected through lungs and gastrointestinal (GI) tract. Limited toxicokinetic data suggest that zinc borate breaks down readily in the stomach to zinc oxide and boric acid.		
Dermal Absorption <i>in vitro</i>				No data located.
Absorption, Distribution, Metabolism & Excretion	Oral, Dermal or Inhaled	No exposure expected through skin but absorption expected through lungs and GI tract. (Estimated by analogy)	Professional judgment	Based on closely related confidential analogs with similar structures, functional groups, and physical/chemical properties.
		Zinc borate readily breaks down to zinc oxide and boric acid in the stomach.	NAS, 2000	Limited study details reported in a secondary source.
Acute Mammalian Toxicity		LOW: Based on acute toxicity values >2,000 mg/kg for the oral and dermal routes of exposure. Data are inadequate to assess inhalation exposure.		
Acute Lethality	Oral	Zinc borate: Rat oral LD ₅₀ >10,000 mg/kg	EPA, 1991 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
		Zinc borate: Rat oral LD ₅₀ >5,000 mg/kg	Cervan, 1992 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
		Zinc borate: Rat oral LD ₅₀ >10,000 mg/kg	Daniels et al., 1969 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
	Dermal	Zinc borate: Rabbit dermal LD ₅₀ >10,000 mg/kg	EPA, 1991 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Inhalation	Zinc borate: (species unspecified) inhalation LC ₅₀ >5 mg/L	EFRA, 2006	Inadequate; no study details reported in a secondary source. Species not identified; not specified if aerosol or dust/fume form.
Carcinogenicity		LOW: There is no evidence of carcinogenicity following exposure to zinc borate or its metabolites zinc oxide and boric acid. Zinc borate is not listed as a known carcinogen by the International Agency for Research on Cancer (IARC), National Toxicology Program (NTP), U.S. EPA or California Proposition 65.		
	OncoLogic Results			No data located.
	Carcinogenicity (Rat and Mouse)	Zinc borate: Not listed as a known carcinogen by IARC, NTP, U.S. EPA, or California Proposition 65.	Maine DEP, 2007	
		Boric acid: 2-year feeding study in rats and dogs. No carcinogenic effects observed in either rats or dogs at doses as high as 58.5 and 40.8 mg/kg-day, respectively.	Weir and Fisher, 1972 (as described in Maine DEP, 2007 and HERA, 2005)	Limited study details reported in a secondary source.
		Boric acid: No carcinogenic effects reported in mice exposed to doses as high as 201 mg/kg-day in an NTP bioassay.	NTP, 1987 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
	Combined Chronic Toxicity/ Carcinogenicity			No data located.
Genotoxicity		HIGH: Potential for mutagenicity based on exposure to zinc. Zinc borate did not cause gene mutations or chromosomal aberrations <i>in vitro</i>. In addition, <i>in vitro</i> and <i>in vivo</i> assays for the metabolite boric acid were negative for genotoxicity.		
	Gene Mutation <i>in vitro</i>	Zinc: Potential for mutagenicity based on exposure to zinc (Estimated)	Professional judgment	Estimated based on professional judgment.
		Zinc borate: Ames assay in <i>Salmonella typhimurium</i> : Negative with and without metabolic activation	EPA, 1991 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.

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PROPERTY/ENDPOINT	DATA	REFERENCE	DATA QUALITY
	Boric acid: Mutation assays in <i>S. typhimurium</i> , <i>Escherichia coli</i> , and mammalian cells (L5178Y mouse lymphoma, V79 Chinese hamster cells, C3H/10T1/2 cells): Negative	Haworth et al., 1983; Landolph, 1985; NTP, 1987; Bakke, 1991; Stewart, 1991 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
Gene Mutation <i>in vivo</i>	Boric acid: <i>In vivo</i> mouse bone marrow micronucleus assay: Negative	O'Loughlin, 1991 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
Chromosomal Aberrations <i>in vitro</i>	Zinc borate: Did not induce chromosomal aberrations <i>in vitro</i> : Negative	EPA, 1991 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
	Boric acid: Chromosomal aberration and sister chromatid exchanges in mammalian cells: Negative	Haworth et al., 1983; Landolph, 1985; NTP, 1987; Bakke, 1991, Stewart, 1991(as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
Chromosomal Aberrations <i>in vivo</i>			No data located.
DNA Damage and Repair	Boric acid: Negative in bacterial DNA-damage assay, unscheduled DNA synthesis in hepatocytes	Haworth et al., 1983; Landolph, 1985; NTP, 1987; Bakke, 1991, Stewart, 1991 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
Other (Mitotic Gene Conversion)			No data located.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reproductive Effects		MODERATE: Estimated based on reproductive system effects following exposure to boric acid. Exposure to boric acid resulted in male reproductive toxicity including increased incidence of testicular atrophy, reduced sperm count, and degeneration of seminiferous tubules.		
	Reproduction/ Developmental Toxicity Screen	Boric acid: Rat 3-generation study; increased incidence of testicular atrophy, degeneration of seminiferous tubules, reduced sperm count and reduced fertility. NOAEL = 17.5 mg boron/kg-day (corresponding to 100 mg boric acid/kg-day) LOAEL = 58.5 mg boron/kg-day (corresponding to 334 mg boric acid/kg-day)	Weir and Fisher, 1972 (as described in Maine DEP, 2007 and HERA, 2005)	Study details reported in a secondary source.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Reproduction and Fertility Effects	Boric acid: Increased incidence of reversible disruption of tubular spermiation in rats administered 175 mg/kg-day LOAEL = 175 mg/kg-day	Linder et al., 1990 (as described in Maine DEP, 2007 and HERA, 2005)	Limited study details reported in a secondary source.
		Boric acid: No reproductive effects reported in rats following exposure to a single dose of 2,000 mg/kg-day NOAEL = 2,000 mg/kg-day	Bouissous and Castagnol, 1965 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
		Boric acid: Increased incidence of reversible inhibition of spermiation in rats administered 217 mg/kg-day for 14 days LOAEL = 217 mg/kg-day	Ku et al., 1993 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Developmental Effects		MODERATE: Estimated based on developmental effects following exposure to zinc oxide, known to be formed from zinc borate in the stomach. Exposure to zinc oxide resulted in increased incidence of stillborn pups. Developmental toxicity data for boric acid exposure in rabbits, rats and mice are consistent with this hazard designation.		
	Reproduction/ Developmental Toxicity Screen			No data located.
	Combined Repeated Dose with Reproduction/ Developmental Toxicity Screen			No data located.
	Prenatal Development	Zinc oxide: Rat, oral (diet) exposure from gestation days (GDs) 0 to lactation day 14; no external malformations were observed. There were no effects on maternal weight, daily food intake, duration of gestation and number of viable young/litter decreased pup dry liver weights. There were 4 stillborn pups (not edematous) in dams of rats exposed to 150 mg/kg-day and 2 females had stillborn litters containing edematous pups in rats exposed to 375 mg/kg-day. LOAEL = 150 mg ZnO/kg-day	Ketcheson et al. 1969 (as described in Maine DEP, 2007 and ESIS, 2008)	Limited study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Boric acid: Rabbit; GD 6-19, oral (gavage); developmental effects. Rabbit: Maternal and Developmental NOAEL = 125 mg/kg-day Maternal and Developmental LOAEL = 250 mg/kg-day Rat: NOAEL = 78 mg/kg-day Mouse: NOAEL = 248 mg/kg- day	U.S. Borax and Chemical Corp, 1992a.	Limited study details reported; TSCATS submission.
	Postnatal Development			No data located.
Neurotoxicity		HIGH: Estimated based on analogy to data for boric acid. Limited data indicate a 4-hour inhalation exposure to boric acid may cause neurotoxic effects in rats at 0.16 mg/L. Limited data were located regarding neurotoxic effects caused by exposure to zinc borate or zinc oxide. There is also potential for developmental neurotoxicity based on boric acid using expert judgment.		
	Neurotoxicity	Boric acid: Rat 4-hour dust inhalation; caused reduced righting reflex, hunched posture, lacrimation and rales LOAEL = 0.16 mg/L	U.S. Borax and Chemical Corp., 1992b	Limited study details reported; TSCATS submission.
		Boric acid: Potential for developmental neurotoxicity (Estimated)	Expert judgment	Estimated based on expert judgment.
		Zinc borate: Not classified as a developmental neurotoxicant.	Grandjean and Landrigan, 2006 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
		Zinc borate: Not listed as a potential neurotoxicant on the Red List of Chemicals	CPA, 2009 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Zinc oxide: Rat, 10-day gavage exposure; degenerative changes and histoenzymatic changes, degenerative changes of neurocytes, accompanied with proliferation of the oligodendroglia, and glial proliferation in the white matter. Histoenzymatic changes including decreased ACP, ATPase, AChE, BChE activity and increased TTPase and NSE activity.	Kozik et al., 1980 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
Repeated Dose Effects		LOW: Estimated based on data for boric acid (a dissociation product of zinc borate). Limited data indicate repeated exposure to boric acid may cause effects including decreased food consumption and body weight gain, clinical signs of toxicity and changes in hematological parameters, though these effects occur at doses of >100 mg/kg-day of boric acid. No repeated dose toxicity data were located for zinc borate or zinc (a dissociation product of zinc borate). There is uncertain potential for immunotoxic effects based on confidential data for other Zn²⁺ compounds.		
		Zinc oxide: Ferrets; oral (feed) 21-day exposure; pale livers with fatty infiltration and enlarged kidneys; macrocytic hypochromic anemia, increased reticulocytes and leucocytosis. Increased severity at higher doses. NOAEL = 81.3 mg/kg-day LOAEL = 243.8 mg/kg-day	Straube et al., 1980 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source. Data are for zinc oxide.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Boric acid: 2-year feeding study in rats and dogs; effects in rats included decreased food consumption and body weight gain, coarse hair coats, hunched position, swollen pads, inflamed bleeding eyes and changes in hematological parameters. Diarrhea and soft stool was observed in dogs. Testicular effects were reported for both rats and dogs. NOAEL = 100 mg boric acid/kg-day LOAEL = 334 mg boric acid/kg-day	Weir and Fisher, 1972 (as described in Maine DEP, 2007 and HERA, 2005)	Limited study details reported in a secondary source. Values from primary source are reported as boron equivalent doses. Doses as boric acid were not reported but are calculated by dividing the boron equivalent doses with the MW of boric acid (0.1750). i.e., NOAEL = 17.5 mg boron/kg-day (corresponding to 100 mg boric acid/kg-day) LOAEL = 58.5 mg boron/kg-day corresponding to 334 mg boric acid/kg-day)
	Immune System Effects	Uncertain potential for immunotoxic effects (Estimated by analogy)	Professional judgment	Based on confidential data for other Zn ²⁺ compounds.
Skin Sensitization		LOW: Zinc borate is not a skin sensitizer in guinea pigs.		
	Skin Sensitization	Zinc borate: Not a skin sensitizer in guinea pigs	U.S. Borax Inc., 1996 (as described in Maine DEP, 2007 and NAS, 2000)	Limited study details reported in a secondary source.
		Boric acid: Not a skin sensitizer in humans or animals	Wnorowski, 1994a,b,c; Bruze et al., 1995 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
Respiratory Sensitization		No data located.		
	Respiratory Sensitization			No data located.
Eye Irritation		LOW: Zinc borate causes no irritation to mild irritation.		
	Eye Irritation	Contact with eyes causes irritation	HSDB, 2011	Limited study details reported in a secondary source.
		Mild conjunctivitis; not considered to be and eye irritant or corrosive, rabbit	U.S. Borax Inc., 1996 (as described in Maine DEP, 2007 and NAS, 2000)	Limited study details reported in a secondary source.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Eye irritant with mild conjunctivitis, rabbit	EPA, 1991 (as described in Maine DEP, 2007)	Limited study details reported in a secondary source.
Dermal Irritation		LOW: Zinc borate may cause skin irritation, but is not corrosive.		
	Dermal Irritation	Contact with skin causes irritation	HSDB, 2011	No study details reported in a secondary source.
		Not irritant or corrosive	EPA, 1991 (as described in Maine DEP, 2007)	No study details reported in a secondary source.
Endocrine Activity		Does not have potential for endocrine activity based on expert judgment.		
		No potential for endocrine activity (Estimated)	Expert judgment	Estimated based on expert judgment.
Immunotoxicity		There is uncertain potential for immunotoxicity based on exposure to zinc ions.		
	Immune System Effects	Uncertain potential for immunotoxic effects (Estimated by analogy)	Professional judgment	Based on confidential data for other Zn ²⁺ compounds.
ECOTOXICITY				
ECOSAR Class		Not applicable		
Acute Toxicity		HIGH: Based on estimated potential for dissolved zinc species to cause adverse effects in aquatic species, as described in the EPA Chemical Categories document which includes all soluble complexes of zinc. (Professional judgment)		
Fish LC ₅₀		Potential for adverse effects in aquatic species. (Estimated)	Professional judgment	Estimated based on aquatic toxicity effects from dissolve zinc species as described in the EPA Chemical Categories document.
		Zinc borate: Classified as Dangerous to the Environment, R50/R53, very toxic to aquatic organisms may cause long-term effects in the aquatic environment. (Experimental)	EFRA, 2006 (as described in Maine DEP, 2007)	Limited study details reported in the database.
		Zinc borate: <i>Lepomis macrochirus</i> (bluegill) 96-hour LC ₅₀ = 335 mg/L (Experimental)	ECOTOX	Limited study details reported in the database.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
		Zinc borate: <i>Oncorhynchus mykiss</i> (rainbow trout) 96-hour LC ₅₀ = 2.7 mg/L (Experimental)	ECOTOX	Limited study details reported in the database.
Daphnid LC ₅₀		Zinc borate: <i>Daphnia magna</i> 48-hour EC ₅₀ = 75 mg/L (Experimental)	ECOTOX	Limited study details reported in the database.
Green Algae EC ₅₀				No data located.
Chronic Aquatic Toxicity		HIGH: Based on estimated potential for dissolved zinc species to cause adverse effects in aquatic species, as described in the EPA Chemical Categories document which includes all soluble complexes of zinc. (Professional judgment)		
Fish ChV		Potential for adverse effects in aquatic species. (Estimated)	Professional judgment	Estimated based on aquatic toxicity effects from dissolve zinc species as described in the EPA Chemical Categories document.
		Zinc borate: Classified as Dangerous to the Environment, R50/R53, very toxic to aquatic organisms may cause long-term effects in the aquatic environment. (Experimental)	EFRA, 2006 (as described in Maine DEP, 2007)	Limited study details reported in the database.
Daphnid ChV				No data located.
Green Algae ChV				No data located.
ENVIRONMENTAL FATE				
Transport		The transport evaluation for zinc borate is based on located experimental and estimated physical/chemical properties. The low water solubility, low vapor pressure (10⁻⁸), estimated high soil adsorption and Henry's Law Constant (<10⁻⁸) indicate that zinc borate will be relatively immobile in the environment. Transport is more likely to occur in water and at low pH, where zinc borate dissociates into zinc and borate ions.		
	Henry's Law Constant (atm-m ³ /mole)	<10 ⁻⁸ (Estimated)	Professional judgment	Cutoff value for nonvolatile compounds such as inorganic salts. This inorganic compound is not amenable to available estimation methods.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
	Sediment/Soil Adsorption/Desorption Coefficient – K_{oc}	Zinc borate is sparingly soluble in water and is not expected to leach through soil. (Estimated)	Professional judgment	Available methods for estimating K_{oc} values cannot be directly applied to inorganic salts.
	Level III Fugacity Model			Not all input parameters for this model were available to run the estimation software (EPI).
Persistence		HIGH: Zinc borate is expected to have high persistence in the environment because of the persistence of Zn^{2+} ions. The behavior of zinc borate in water is complex. In acidic aqueous conditions zinc borate releases Zn^{2+} and boric acid; the Zn^{2+} will not undergo further degradation (but can undergo precipitation, sorption, or ligand exchange reactions in the environment). In basic aqueous conditions, zinc borate forms boric acid and hydrated zinc oxide. Zinc borate was found to be stable in sunlight, under normal and elevated temperatures, according to an EPA guideline study.		
Water	Aerobic Biodegradation			No data located.
	Volatilization Half-life for Model River			No data located.
	Volatilization Half-life for Model Lake			No data located.
Soil	Aerobic Biodegradation			No data located.
	Anaerobic Biodegradation			No data located.
	Soil Biodegradation with Product Identification			No data located.
	Sediment/Water Biodegradation			No data located.
Air	Atmospheric Half-life	>1 year (Estimated)	Professional judgment	Substance is or contains inorganic elements such as metal ions or oxides that are not amenable to atmospheric degradation processes.

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PROPERTY/ENDPOINT		DATA	REFERENCE	DATA QUALITY
Reactivity	Photolysis	Stability to sunlight, normal and elevated temperature, according to EPA Method 830.6313 for metals/metal ions (for 12447-61-9) (Estimated by analogy)	Gowda, 2007	Adequate; guideline study.
	Hydrolysis	<10 minutes at pH 6 48 hours at pH 9 (for 12447-61-9) (Estimated by analogy)	Lords, 2007	Adequate; formation of insoluble hydrated zinc oxide precipitate occurs at a pH of 9.
Environmental Half-life				Not all input parameters for this model were available to run the estimation software (EPI).
Bioaccumulation		LOW: Zinc borate is not expected to be very soluble in water and therefore does not have potential for bioaccumulation.		
	Fish BCF	<100 (Estimated)	Professional judgment	This inorganic compound is not amenable to available estimation methods.
	BAF	<100 (Estimated)	Professional judgment	This inorganic compound is not amenable to available estimation methods.
	Metabolism in Fish			No data located.
ENVIRONMENTAL MONITORING AND BIOMONITORING				
Environmental Monitoring		No data located.		
Ecological Biomonitoring		No data located.		
Human Biomonitoring		This chemical was not included in the National Health and Nutrition Examination Survey biomonitoring report (CDC, 2011).		

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