



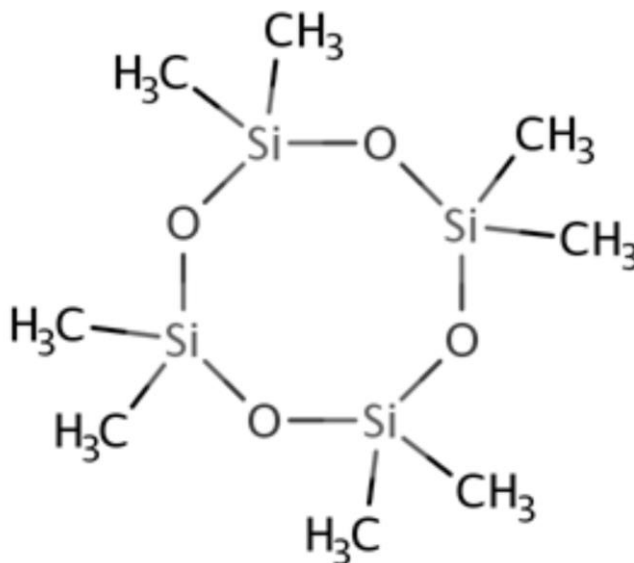
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Draft Consumer and Indoor Dust Exposure Assessment for Octamethylcyclotetrasiloxane (D4)

Technical Support Document for the Risk Evaluation

CASRN 556-67-2



September 2025

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	5
SUMMARY	6
1 INTRODUCTION.....	8
2 CONSUMER EXPOSURE APPROACH AND METHODOLOGY	11
2.1 Products and Articles with D4 Content	12
2.1.1 Solid Articles	13
2.1.2 Liquid and Paste Products	15
2.1.3 Linkages to Occupational Exposure Scenarios.....	21
2.2 Disposal COU.....	22
2.3 Modeling Inhalation of D4 Emitted from Liquid and Paste Products.....	25
2.3.1 Selected CEM 3.2 Models	26
2.3.2 Modeling Inputs and Parameterization	27
2.4 Modeling Inhalation of D4 Emitted from Solid Articles.....	33
2.4.1 Modeling Inputs and Parameterization	33
2.5 Dermal Modeling Approach.....	34
2.5.1 Dermal Dose Modeling for Liquid and Paste Products	35
2.5.2 Dermal Uptake Modeling for Contact with Solid Articles	37
2.6 Mouthing Modeling Approach	39
2.6.1 Modeling Inputs and Parameterization for Estimating Mouthing Exposure to D4 Emitted from Solid Articles	39
3 CONSUMER EXPOSURE MODELING RESULTS.....	43
3.1 Non-Cancer Acute Dose Results, Conclusions, and Data Patterns	43
3.2 Intermediate Average Daily Dose Results, Conclusions, and Data Pattern	49
3.3 Non-Cancer Chronic Dose Results, Conclusions, and Data Patterns.....	52
4 INDOOR AIR AND DUST MONITORING STUDIES.....	58
5 WEIGHT OF SCIENTIFIC EVIDENCE	61
5.1 Consumer Exposure Analysis Weight of Scientific Evidence	61
6 STEPS TOWARDS RISK CHARACTERIZATION.....	69
REFERENCES.....	70
Appendix A ACUTE, CHRONIC, AND INTERMEDIATE DOSE RATE EQUATIONS	75
A.1 Acute Dose Rate (ADR)	75
A.2 Non-Cancer Chronic Dose	78
A.3 Intermediate Average Daily Dose	80

List of Tables

Table 1-1. Consumer Conditions of Use Table	9
Table 2-1. Summary of Consumer COUs, Exposure Scenarios, and Exposure Routes	18
Table 2-2. Use of Residual D4-Containing Products OES to Industrial and/or Commercial COUs Crosswalk.....	21
Table 2-3. Consumer COUs Represented by Industrial and/or Commercial Uses of Residual D4 Containing Products OES	22
Table 2-4. Summary of Mean Surface Water and Sediment Concentrations from All Sampled	

68	WWTPs in the ECA (ERM, 2017a, b).....	24
69	Table 2-5. CEM 3.2 Model Codes and Descriptions Used to Model D4	26
70	Table 2-6. Crosswalk of COUs, CEM 3.2 Scenarios, and Relevant CEM 3.2 Models Used for	
71	Consumer Modeling.....	26
72	Table 2-7. Summary of Key Parameters for Products Modeled in CEM 3.2	31
73	Table 2-8. Key Parameters Used to Model Dermal Uptake from Liquid and Paste Products.....	36
74	Table 2-9. Key Parameters Used to Model Dermal Uptake from Solid Articles	38
75	Table 2-10. Mouthing Durations for Children for Toys and Other Objects	40
76	Table 2-11. Key Inputs for Mouthing Models	42
77	Table 3-1. Acute Exposure Concentrations of D4 in Air Emitted from Consumer Products and	
78	Articles (mg/m ³).....	48
79	Table 3-2. Intermediate Exposure Concentrations of D4 in Air Emitted from Consumer Products and	
80	Articles (mg/m ³).....	51
81	Table 3-3. Chronic Exposure Concentrations of D4 in Air Emitted from Consumer Products and	
82	Articles (mg/m ³).....	56
83	Table 5-1. Weight of Scientific Evidence Summary per Consumer COU	64

84

85 **List of Figures**

86	Figure 3-1. Acute Dose Rate for Ingestion, Inhalation, and Dermal Exposure Routes for Infants (<1	
87	Year Old) and Toddlers (1–2 Years Old).....	45
88	Figure 3-2. Acute Dose Rate for Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers	
89	(3–5 Years Old) and Middle Childhood (6–10 Years Old).....	46
90	Figure 3-3 Acute Dose Rate for Inhalation and Dermal Exposure Routes for Young Teens (11–15	
91	Years Old) and Teenagers and Young Adults (16–20 Years Old).....	47
92	Figure 3-4 Acute Dose Rate for Inhalation and Dermal Exposure Routes for Adults (20+ Years Old) ..	48
93	Figure 3-5. Intermediate Dose Rate for Inhalation Exposure for Infants (<1 Year Old) and Toddlers	
94	(1–2 Years Old) as Bystanders	50
95	Figure 3-6. Intermediate Dose Rate for Inhalation Exposure Routes for Preschoolers (3–5 Years Old)	
96	and Middle Childhood (6-10 Years Old) as Bystanders	50
97	Figure 3-7. Intermediate Dose Rate for Inhalation and Dermal Exposure Routes for Young Teens	
98	(11–15 Years Old) and Teenagers and Young Adults (16–20 Years Old)	51
99	Figure 3-8. Intermediate Dose Rate for Inhalation and Dermal Exposure Routes for Adults (20+	
100	Years Old)	51
101	Figure 3-9. Chronic Average Daily Dose for Ingestion, Inhalation, and Dermal Exposure Routes for	
102	Infants (<1 Year Old) and Toddlers (1-2 Years Old).....	53
103	Figure 3-10 Chronic Average Daily Dose for Ingestion, Inhalation, and Dermal Exposure Routes for	
104	Preschoolers (3–5 Years Old) and Middle Childhood (6-10 Years Old).....	54
105	Figure 3-11 Chronic Average Daily Dose for Inhalation and Dermal Exposure Routes for Young	
106	Teens (11–15 Years Old) and Teenagers and Young Adults (16–20 Years Old).....	55
107	Figure 3-12 Chronic Average Daily Dose for Inhalation and Dermal Exposure Routes for Adults (20+	
108	Years Old)	56
109	Figure 4-1. Concentrations of D4 in Indoor Air for Non-U.S. Studies	59

110

ABBREVIATIONS AND ACRONYMS

112	ACC	American Chemical Council
113	ADR	Acute dose rate
114	ADD	Average daily dose
115	CADD	Chronic Average Daily Dose
116	CDC	Center for Disease Control and Prevention
117	CDR	Chemical Data Reporting
118	CEM	Consumer Exposure Model
119	COU	Condition of use
120	D4	Octamethylcyclotetrasiloxane
121	DIY	Do-it-yourself
122	OCSP	Office of Chemical Safety and Pollution Prevention
123	OPPT	Office of Pollution Prevention and Toxics
124	SDS	Safety Data Sheet
125	SVOC	Semi-volatile organic compound
126	TSCA	Toxic Substances Control Act

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Docket

Supporting information can be found in the public docket, Docket ID [EPA-HQ-OPPT-2018-0443](#).

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SUMMARY

This technical document is in support of the Toxic Substances Control Act (TSCA) *Draft Risk Evaluation for Octamethylcyclotetrasiloxane (D4) CASRN 556-67-2* ([U.S. EPA, 2025h](#)). This document describes the assessment of consumer and indoor exposures to D4 resulting from relevant conditions of use (COUs). D4 is primarily used as an intermediate to produce other silicone polymers. Consumer COUs of D4 include adhesives, sealants, automotive care products, laundry and dishwashing products, paints and coatings, plastic and rubber products, and textiles and apparel. EPA conducted a comprehensive search of multiple data and information searches to identify the relevant COUs for this assessment (details are available in the *Final Scope of the Risk Evaluation for Octamethylcyclotetrasiloxane (Cyclotetrasiloxane, 2,2,4,4,6,6,8,8-octamethyl-) (D4)*; CASRN 556-67-2 ([U.S. EPA, 2022](#))). Table 1-1 lists the consumer COUs that are in scope. Some of these consumer uses also have occupational/commercial applications, and the evaluation of exposure and risks can be found in *Draft Environmental Release and Occupational Exposure Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025e](#)).

This assessment considers human exposure to D4 in consumer products and articles resulting from COUs as defined under TSCA. D4 in articles such as textile and apparel can exist as a contaminant or serve a chemical function (*e.g.*, plasticizer, softener) depending on the specific item. Examples of products and articles containing D4 and their variable D4 levels are detailed in Section 2.1. The major routes of exposure considered were ingestion via mouthing of articles (*i.e.*, toys that may contain intentionally added D4 or D4 as a residual), inhalation, and dermal exposure. Dermal exposure is possible through direct application or contact with formulated products to skin, as well as partitioning of D4 from solid to sweat or skin. Despite D4's volatility and hydrophobicity, D4 adherence to organic compounds in the skin and thus absorption through the skin is possible.

EPA used a variety of tools and modeling techniques to meet the unique needs of generating parameterized scenarios and resulting exposure estimates given the available data. For inhalation exposure to liquid and paste products, EPA used the Consumer Exposure Model (CEM) to estimate acute and chronic exposures to consumer users and bystanders. For inhalation exposure to D4 in solid articles, EPA used the Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones (IECCU) model to estimate acute and chronic exposures to consumer users and bystanders. Acute exposures were for an exposure duration of one day, intermediate exposures for a duration of 30 days, and chronic exposures for an exposure duration of one year. Confidence in the estimates were classified as robust, moderate, or slight depending on the quality and volume of the data available for specific products or article scenarios. For each scenario, low, medium, and high exposure scenarios were developed in which values for weight fraction, duration of use, frequency of use, and surface area were determined based on reasonably available information and professional judgment. Ingestion by mouthing to solid articles, as well as dermal exposures for both liquid products and solid articles were calculated in outside of CEM, see *Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025b](#)). Low, medium, and high exposure scenarios were developed for each product and article scenario by varying values for weight fraction and duration of contact. Mouthing duration and chemical migration rate from solid to saliva were unique parameters for the ingestion exposure estimates. The area of exposed skin was applicable to only the dermal exposure estimates. Confidence in the ingestion and dermal exposure estimates were robust or moderate depending on the quality and volume of available data for characterizing the scenarios.

The exposure estimates in this document represent potential doses per unit of body weight rather than actual absorbed doses. In other words, it estimates the total dose of chemical ingested, dermally absorbed, or inhaled without regard for absorption efficiency. Only potential doses were estimated

because the human hazard values used to characterize risks were derived from a physiologically-based pharmacokinetics (PBPK) model that already accounts for absorption and internal distribution (see *Draft Human Health Hazard Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025f](#))).

The resulting exposure estimates varied across scenarios, products, and routes by orders of magnitude. For the inhalation route, paints and lacquers used in both small indoor and large outdoor projects contributed the most to acute exposure, particularly for product users (youth and adults). Inhalation exposures to these products for children, modeled as bystanders who are not in the direct vicinity of the products during use, also resulted in the highest potential for acute inhalation exposure among this age group. Chronic inhalation exposure was highest for bedding and laundry detergent where routine use is expected. Air exposure concentrations across all consumer COUs, exposure durations (*i.e.*, acute, intermediate, and chronic), use intensities, and age groups ranged from 4.6×10^{-7} to 40 mg/m^3 . When the air exposure concentrations are used to calculate an inhalation dose, the values range from 1.6×10^{-8} to 11 mg/kg-day . Dermal exposures to liquid products during use were highest for adults and youth, while dermal exposures to plastic and rubber toys, bedding, and clothing were notable for infants and children. Dermal exposure estimates across all consumer COUs, exposure durations (*i.e.*, acute, intermediate, and chronic), use intensities, and age groups ranged from 5.4×10^{-6} to 22 mg/kg-day . Overall, ingestion by mouthing for all relevant age groups across all COUs were low compared to other exposure routes (5.5×10^{-9} to $5.5 \times 10^{-3} \text{ mg/kg-day}$). These results indicate that exposure patterns may differ for consumer products by age groups and exposure routes.

1 INTRODUCTION

On March 19, 2020, EPA received a request, pursuant to 40 CFR 702.37, from Dow Silicones Corporation, Elkem Silicones USA Corporation, Evonik Corporation, Momentive Performance Materials, Shin-Etsu Silicones of America, Inc., and Wacker Chemical Corporation through the American Chemistry Council's Silicones Environmental, Health, and Safety Center (ACC SEHSC), to conduct a risk evaluation for octamethylcyclotetrasiloxane (D4) (CASRN 556-67-2) (Docket ID: EPA-HQOPPT-2018-0443). This chemical substance is listed in the 2014 Update to the TSCA Work Plan as "octamethylcyclotetra- siloxane" and is assigned a CA Index Name of "Cyclotetrasiloxane, 2,2,4,4,6,6,8,8-octamethyl-." It is most commonly referred to as Octamethylcyclotetrasiloxane and will be abbreviated in this document as "D4."

In their request, ACC SEHSC identified specific consumer products and articles likely to contain D4. "Products" are consumable liquids, aerosols, or semi-solids that are used a given number of times before they are exhausted ([U.S. EPA, 2023](#)). "Articles" are solids, polymers, foams, metals, or woods, which are present within indoor environments for the duration of their useful life, which may be several years ([U.S. EPA, 2023](#)). Consumer products containing D4 include adhesives and sealants, automotive care products, cleaning and furnishing care products, paints and coatings, polishes and cleaning products, and detergents. Consumer articles containing D4 include textiles and apparel, children's toys, plastic and rubber items meant to be mouthed, and plastic and rubber in footwear. Consumer COUs that were identified as being in scope for this assessment are listed in Table 1-1.

The migration of D4 from consumer products and articles is a potential mechanism of exposure. However, the relative contribution of various consumer goods to overall exposure to D4 has not been well characterized. The identified uses can result in exposures to consumers and bystanders (non-product users that are incidentally exposed to the product). For all the D4-containing consumer products identified, the exposure analysis involves addressing the inherent uncertainties by modeling low, medium, and high exposure scenarios. Low, medium, and high exposure scenarios were developed by varying key parameters relevant to each route. For example, duration of use, frequency of use, and surface area of article were applicable to inhalation and ingestion. High-end values determined based on reasonably available information and professional judgment would correspond to a high exposure scenario. For dermal exposure, duration of dermal contact and area of exposed skin were varied between the low, medium, and high exposure scenarios. Due to the lack of comprehensive data on various parameters and the expected variability in exposure pathways, EPA used conservative consumptions to obtain exposure doses associated with D4 across COUs to various age groups.

The known presence of D4 in consumer products and articles indicates there is potential for exposure to consumers, but the magnitude of these exposure and the relative contributions of various exposure pathways and routes have not yet been characterized. The identified uses can result in exposures to consumers and bystanders (non-product users that are incidentally exposed to the product). Due to the lack of comprehensive data on various parameters and the expected variability in exposure pathways, EPA used conservative assumptions to estimate potential exposure associated with D4 across COUs to various age groups. For all the D4-containing consumer products and articles identified, the exposure analysis involved addressing the inherent uncertainties by modeling low, medium, and high exposure scenarios. Low, medium, and high exposure scenarios were developed by varying key parameters relevant to each route (*i.e.*, ingestion, inhalation or dermal exposures). High-end values determined based on reasonably available information and professional judgment were assumed to parameterize high exposure scenarios. For example, duration of product use, frequency of product use, and article surface area were applicable to inhalation and ingestion. For dermal exposure, duration of dermal contact and area of exposed skin were varied between the low, medium, and high exposure scenarios.

271 **Table 1-1. Consumer Conditions of Use Table**

Life Cycle Stage	Category	Subcategory of Use	Reference(s)
Consumer	Adhesives and sealants	Adhesives and sealants	U.S. EPA (2022) ; Nuco (2021) ; SAF-T-LOK (2018) ; White Lightning (2024) ; 3M (2018) ; Momentive (2017) ; 3M (2024) ; Silco Inc (2015) ; Dow Corning (2017)
	Automotive care products	Automotive care products	U.S. EPA (2022) ; ITW Global Brands (2021a) ; Oil-Chem Research Corporation (2019) ; Surf City Garage (2015a) ; ITW Global Brands (2021b) ; Surf City Garage (2015b) ; RJ Star (2016) ; Turtle Wax Limited (2020) ; 3M (2020) ; Jax Wax (2018) ; Mothers (2018)
	Furnishing, cleaning, treatment/care products	Cleaning and furnishing care products	U.S. EPA (2022) ; Exponent (2024) ; Horii and Kannan (2008) ; C.R. Laurence (2019) ; Spartan Chemicals (2015)
		Fabric, textile, and leather products not covered elsewhere	U.S. EPA (2022) ; (Faultless, 2019)
		Laundry and dishwashing products	U.S. EPA (2022) ; Gelest (2025) ; Chen et al. (2019) ; Dow Chemical (2022) ; P&G (2025)
	Other	Animal grooming products	U.S. EPA (2022) ; Exponent (2024)
	Packaging, paper, plastic, hobby products	Plastic and rubber products not covered elsewhere	U.S. EPA (2022) ; WSDE (2020)
		Toys, playground, and sporting equipment	U.S. EPA (2022) ; (WSDE, 2020)
	Paints and coatings	Paints and coatings	U.S. EPA (2022) ; UGL (2023) ; Rust-Oleum (2023b) ; Benjamin Moore (2024) ; Old Masters (2020) ; Rust-Oleum (2023a)
	Textiles and apparel	Textiles and apparel	U.S. EPA (2022) ; WSDE (2023) ; WSDE (2020)
	Working fluids	Brake fluid ^a	TCC (2017)
	Polyurethane foam	Polyurethane foam ^a	U.S. EPA (2020) ; (U.S. EPA, 2025i)
	Oil and gas products	Diesel fuel additive ^a	Momentive (2019)
Disposal	Disposal	Disposal	U.S. EPA (2022)

Life Cycle Stage	Category	Subcategory of Use	Reference(s)
^a Analysis of these consumer COUs conducted with an OES as described in Section 2.1.3.			

272

2 CONSUMER EXPOSURE APPROACH AND METHODOLOGY

The consumer exposure assessments considered a number of scenarios based on the available information for specific products and articles. These include the use of a product in a do-it-yourself (DIY) or other application scenario, D4 emission during product use, or contact with an article. The main steps in performing the D4 consumer exposure assessment are summarized below:

- 1) Identification and mapping of product and article examples following the consumer COU table (Table 1-1).
- 2) Compilation of products and articles according to manufacturer's use instructions to determine patterns of use.
- 3) Selection of exposure routes and exposed populations according to product/article use descriptions.
- 4) Identification of data gaps and further search to fill gaps with studies, chemical surrogates or product and article proxies, or professional judgment.
- 5) Selection of appropriate modeling tools based on available information and chemical properties.
- 6) Gathering of input parameters per exposure scenario.
- 7) Parameterization of selected modeling tools and generation of exposure estimates for the relevant scenarios, routes, and population groups.

Consumer products and articles containing D4 were matched with TSCA COUs appropriate for the anticipated use of the item. Table 2-1 summarizes the consumer exposure scenarios by COU for each product example(s), the relevant exposure routes, and whether the analysis was done qualitatively or quantitatively. A qualitative analysis discussed exposure potential based on physical and chemical properties or monitoring data, if available, but exposure was not quantified. A quantitative analysis was conducted when the exposure route was deemed relevant based on product or article use description, and sufficient data were available to parameterize the model. For example, ingestion was not expected for any of the products and thus not evaluated. In a quantitative analysis, exposure from the consumer COUs was estimated by modeling. Each product or article was individually assessed to determine whether all or some exposure routes were applicable, and approaches were developed accordingly.

Due to the physical and chemical properties of D4, the inhalation route assessment included only inhalation of gas-phase emissions and aerosols. D4 is a volatile organic compound (VOC) which is expected to transition readily from liquid and solid consumer goods to the air. Once emitted to the air, partitioning to airborne dust and particulate matter is expected to be negligible (see the *Draft Physical Chemistry and Fate Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025g](#)). As such, D4 exposure via inhalation of gas-phase emissions and aerosols was evaluated through modeling but not ingestion of airborne/suspended and settled dust ingestion. Exposure via inhalation during use of liquid and paste products was modeled using EPA's CEM Version 3.2 ([U.S. EPA, 2023](#)). While this model was designed to model exposures to semi-volatile organic compounds (SVOCs), the equations used for liquid and paste products are appropriate for both SVOCs and VOCs. However, the equations for emissions of chemicals from solid articles contain simplifying assumptions specific to SVOCs that generally overestimate exposure and were therefore deemed inappropriate for modeling emissions of VOCs. As such, inhalation from solid articles was modeled in EPA's Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones (IECCU) model Version 1.1.

Exposure through dermal contact and ingestion during mouthing of consumer goods was also modeled. Several modeling approaches were applied, each of which was chosen based on appropriateness given

the specific chemical characteristics of D4 and type of consumer good. Calculations for dermal exposure to D4-containing consumer products and ingestion by mouthing were carried out using equations outside of CEM and IECCU. Refer to the dermal modeling approach in Section 2.4 and mouthing modeling approach in Section 2.5 for detailed descriptions.

EPA used a low (minimum or 10th percentile), average or median depending on data availability, and a high (95th percentile or maximum) value of critical input parameters (e.g., duration of use, mass of product used, dermal surface area) where possible to characterize low, medium, and high route-specific exposures for each given condition of use. Weight fraction is another important input, but sufficient data were not available to generate a distribution. As such, when only a range were reported like for weight fraction, EPA used the minimum and maximum of the range as the low and high values, with the average of the minimum and maximum used for the medium scenarios. The current TSD presents the main inputs (e.g., weight fraction, duration, use frequency) for the consumer analysis, while all inputs, sources of information, assumptions, and exposure scenario descriptions are available in the supplemental *Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025b](#)).

EPA assessed exposures to D4 from consumer COUs for different averaging times. For acute exposures, also referred to as the acute dose rate (ADR), the estimated dose is for a given day and represents the maximum time-integrated dose over a 24-hour period in which the exposure event occurred. For chronic exposure, also referred to as the average daily dose (ADD), the dose was calculated iteratively at 30-second intervals during the first 24 hours and every hour after that for 60 days and averaged over one year. An intermediate exposure estimate is defined as the exposure to continuous or intermittent (depending on product) use during a 30-day period. Product use instructions or descriptions, consumer reviews, or professional judgment were used to estimate the number of events per day, month, or year. Whenever professional judgment was used, EPA provided a rationale and description of selected parameters.

2.1 Products and Articles with D4 Content

The preferred data sources for D4 content in U.S. consumer goods were (1) safety data sheets (SDS) for specific products or articles with reported D4 content, (2) peer-reviewed literature providing measurements of D4 in consumer goods purchased in the U.S., and (3) government reports and databases originating in the U.S. with manufacturer reported concentrations. When no data could be found for a specific type of product or article identified as likely to contain D4, weight fractions provided by ACC SEHSC for general classes of items were used. ACC SEHSC reported that products with the potential for generation of aerosols typically contained 1 to 5 percent D4 ([Exponent, 2024](#)). Weight fractions of D4 in specific items obtained from these sources are discussed in detail Sections 2.1.1 and 2.1.2. While EPA consulted the 2016 and 2020 data reported in the Chemical Data Reporting (CDR) database, D4 weight fractions in CDR were not used as they may pertain to a finished good in the product category reported, or it could represent a chemical additive which will be added to other components during the manufacturing of the finished good.

EPA further evaluated the products and articles identified to ensure that data represented items currently available to U.S. consumers. Where possible, SDSs were cross-checked with company websites to ensure each product could reasonably be purchased by consumers. In instances where a product or article could not be purchased by a consumer, EPA did not evaluate the item in a do-it-yourself (DIY) or application scenario but determined whether consumers might reasonably be exposed to the specific item as part of a purchased good. In addition to weight fractions, EPA obtained additional information about physical characteristics and potential uses of specific products and articles from technical

specifications, manufacturer websites, and vendor websites. These data were used in the assessment to define exposure scenarios. The following section summarizes specific products and articles with D4 content identified for each item, and Table 2-1 provides a summary of TSCA COUs determined for each item and exposure scenarios modeled.

2.1.1 Solid Articles

The primary data source for all solid articles and textile items was the Washington State Product Testing Database (WAPTD) ([WSDE, 2023](#)) and the High Priority Chemicals Data System (HPCDS) database ([WSDE, 2020](#)). WAPTD publishes product testing results conducted by the Washington Department of Ecology to check for manufacturer's compliance with the state's Children's Safe Products Act. It includes individual concentrations and reporting limits. D4 was analyzed in children's products purchased from a variety of stores during two testing studies in 2014/2015 and 2019 ([WA DOE, 2017, 2015](#)). The HPCDS is managed by the Interstate Chemicals Clearinghouse (IC2) and aggregates data reported under state chemical disclosure laws like Oregon's Toxic-Free Kids Act (TFKA), Washington's Children's Safe Products Act (CSPA), and Vermont's Chemical Disclosure Program (CDP). The database is populated by manufacturer reported values for chemical concentrations in products using predefined concentration categories (bins), rather than exact values. HPCDS does not identify specific consumer products; rather, it reports the presence of a chemical within product categories (*e.g.*, shirts, pants, sleepwear) and lists the component (*e.g.*, textile, inks, dyes, coating) in which the chemical is found. However, in the case of Vermont's CDP Product and Brand Database, additional product details such as brand name, product model, and Universal Product Code (UPC) are included ([VT DOH, 2025](#)). This means that while HPCDS data alone does not pinpoint exact items, cross-referencing it with Vermont's brand names can sometimes help determine the specific products associated with reported chemicals.

Potential exposure by inhalation of D4 emitted from solid articles, dermal uptake during direct contact, and ingestion during mouthing was considered for all articles, but only pathways expected to have the potential for significant exposure were quantitatively assessed. The majority of articles identified with D4 content had very low chemical concentrations (less than 1.0 percent by weight), resulting in limited potential for emissions and low potential for exposure by inhalation after dilution in air. Consequently, inhalation exposure for items with small surface area of emissions (less than 1 m²) was assumed to be insignificant as compared to exposure by mouthing and dermal contact. As such, inhalation exposure was not assessed for these items. Similarly, items not expected to be mouthed on a routine basis (*e.g.*, footwear and putties) were not assessed for mouthing exposure.

Textiles and Apparel

Fabric, textile, and apparel items were assessed for D4 exposure by inhalation, dermal, and ingestion routes. Both WAPTD and HPCDS reported measurable concentrations of D4 in a variety of fabrics and textiles. WAPTD detected D4 in 8 out of the 59 articles of clothing, fabric footwear, bedding, and soft toys tested. The concentrations in those eight samples ranged from 0.027 to 1.21 ppm (2.7×10^{-6} to 1.2×10^{-4} percent).

HPCDS reported D4 content in 1,097 textile items including a variety of clothing items, bibs, fabric footwear, bedding, and textile toy components. Among these items, 107 were reported to have D4 concentrations at less than 0.01 percent, and the remainder were reported to have D4 concentrations between 0.01 to 0.05 percent.

Since D4 concentrations in fabric and textile items were low overall and the small amount of variability exhibited could not be attributed to any difference among item types, weight fractions for all items were

grouped together for modeling. The upper limit of the concentration ranges from HPCSD, weight fraction of 0.05 percent, was used for the high exposure scenario. The lower limit of the concentration ranges from HPCSD, weight fraction of 0.01 percent, was used for the medium exposure scenario. The average detected concentration from WAPTD, weight fraction of 3.0×10^{-5} percent was used for the low exposure scenario. Exposure scenarios for D4 in fabric and textiles were designed to capture the highest potential consumer exposures via inhalation, dermal contact, and ingestion. Given the large number of textile items reported, it was not practical to model exposure for each individually. Instead, three representative products expected to result in the highest exposure were selected based on key factors: surface area available for emission (inhalation), duration and area of skin contact (dermal), and likelihood of mouthing (ingestion). Accordingly, consumer exposure to D4 from fabric and textiles was modeled using scenarios for bedding, clothing items with significant dermal contact area and duration (e.g., pants, shirts), and soft toys.

Plastic and Rubber Items Meant to be Mouthed

Plastic and rubber items designed for mouthing were assessed for D4 exposure by ingestion only because exposure to D4 from other routes are expected to be comparatively negligible given the small surface area for emissions and limited dermal contact area. D4 content in one teething necklace, one pacifier, one bottle nipple, and one toothbrush were reported in WAPTD to be between 0.125 to 104 ppm (1.25×10^{-5} to 0.01 percent), with an average value of 26 ppm (0.0026 percent) among the four items. Based on these data, D4 weight fractions used in low, medium, and high exposure scenarios were 1.25×10^{-5} percent, 0.0026 percent, and 0.01 percent, respectively.

Plastic and Rubber in Footwear

Plastic and rubber in footwear were assessed for D4 exposure only by the dermal route because exposure to D4 from other routes are expected to be comparatively negligible given the small surface area for emissions and limited opportunities for mouthing. HPCDS reported D4 content in 1,149 footwear items. Among these items, four were reported to have D4 concentrations less than 0.01 percent, and 1,145 items were reported to have D4 concentrations between 0.01 to 0.05 percent. Based on these data, the weight fractions used in low, medium, and high exposure scenarios were 0.01 percent, 0.03 percent, and 0.05 percent, respectively.

Children's Toys

HPCSD contained data for D4 measurements in 211 non-textile toy items. Some of these items were identified for use in arts and crafts but EPA considered them as toys in this assessment after determining expected use patterns. The concentration ranges and number of items measuring a concentration within each range are provided below.

Concentration Range	Number of Items
<0.05%	196
0.05–0.1%	6
0.1–0.5%	3
0.5–1%	1
≥1%	5

By aligning brand names, product categories, and components across both the HPCDS and Vermont databases, EPA could infer which specific items contained D4 and at what levels. Some items had

relatively unique product category-component combinations (e.g., puzzles-homogenous mixture, jewelry craft supplies-homogenous mixture) that allowed for a high level of confidence that the correct product was matched. Among items with D4 at levels exceeding 0.05 percent, ten were determined to be putties and other viscoelastic toys, four were moving puzzles with lubricated interior parts, and one was a silicone rubber toy. Among the toy items with D4 content below 0.05 percent, there is significant variability in type of item and specific component reported, but EPA determined the majority are likely composed of plastic and rubber.

A total of 15 items reported in HPCDS and WAPTD were identified as putties and other viscoelastic toys. About half of them were silicone putties designed to remain soft and flexible with repeated handling. The other half were crafting kits that produce soft, flexible polymers for a variety of uses such as wall clings, suncatchers, and beads used to make jewelry. While the individual components of the crafting kits have small volumes and surface areas, once formed into other structures, these items often function as toys with similar mechanical properties and anticipated use patterns as putties. As such, all items in this group were considered together for modeling. The minimum, average, and maximum reported concentrations for these items (0.01 percent, 0.5 percent, and 1.0 percent) were used to develop low, medium, and high exposure scenarios. These items were modeled for only dermal exposure because other routes are expected to be comparatively negligible given the small surface area for emissions and limited opportunities for mouthing.

Weight fraction data for a total of 204 plastic and rubber toys informed the concentration data used to model D4 exposure via the dermal and ingestion by mouthing routes. One item was reported with D4 concentration between 0.5 and 1 percent, three were reported with D4 concentration less than or equal to 0.01 percent, and 200 were reported with D4 concentrations between 0.01 and 0.05 percent. The minimum, average, and maximum reported concentrations for these items (0.01 percent, 0.03 percent, and 0.1 percent) were used to populate low, medium, and high exposure scenarios.

Based on an initial analysis, EPA did not model moving puzzles with lubricated interior parts for exposure because the component with D4 content appeared to be inaccessible to users and therefore was not expected to result in significant exposure. Furthermore, the D4 contents reported for these items was within the range of reported values as other toy items modeled.

2.1.2 Liquid and Paste Products

Adhesives and Sealants for Home DIY Projects

A variety of adhesives and sealants were identified for home DIY applications, including five caulking and sealing compounds designed for both indoor and outdoor use. These products were sold in a variety of formats and differ from standard caulk in their specialized properties, such as high heat resistance, chemical resistance, and enhanced durability against weather exposure. The weight fractions of D4 reported for these products were 0.05 to 0.1 percent ([Nuco, 2021](#)), 0.1 to 1 percent ([SAF-T-LOK, 2018](#)), less than 1 percent ([White Lightning, 2024](#)), less than or equal to 1 percent ([3M, 2018](#)), and one to three percent ([Momentive, 2017](#)).

Three special purpose adhesive and sealant products with D4 content were also identified including a marine sealant, a food safe silicone sealant, and a concrete joint caulk. The marine sealant reported D4 content at less than 0.1 percent ([3M, 2024](#)); reviews from online retailer websites indicated that consumers commonly use this product for off-label applications including a wide range of home repairs such as bath and kitchen caulking, ceiling repair, window installation. The food safe silicone sealant had a reported D4 content less than 1 percent ([Silco Inc, 2015](#)). The concrete joint caulk had a reported D4

content of 0.03 to 0.22 percent ([Dow Corning, 2017](#))

Adhesives and sealants were modeled for inhalation and dermal exposures resulting from contact during use. While the use patterns for these different product types may differ slightly, they were grouped together for modeling under the assumption that the range of use patterns will be captured by low-, medium-, and high-intensity use scenarios as described in Section 2.3. Based on these data, the weight fractions of D4 used in low, medium, and high exposure scenarios for these products were 0.03 percent, 0.01 percent, and 3.0 percent. The weight fraction for the medium scenario is the average of the weight fraction among all available SDSs.

Automotive Care Products

Ten spray-on products were identified for vehicle maintenance, including exterior wax and tire shine products ([ITW Global Brands, 2021a, b](#); [3M, 2020](#); [Turtle Wax Limited, 2020](#); [Oil-Chem Research Corporation, 2019](#); [Jax Wax, 2018](#); [Mothers, 2018](#); [RJ Star, 2016](#); [Surf City Garage, 2015a](#)). Among these products, the lowest reported weight fraction of D4 was 0.05 percent, the mean reported value was 2.4 percent, and the highest reported value was 10 percent; these values were used in low, medium, and high exposure scenarios. Automotive care products were modeled for inhalation and dermal exposures resulting from contact during use.

Furnishing, Cleaning, Treatment/Care Products

The ACC SEHSC provided EPA with a human health risk assessment for spray products, stating that typical D4 content in these products ranges from 1 percent to 5 percent ([Exponent, 2024](#)). Additionally, EPA identified two spray-on cleaning products and one fabric finishing spray product with D4 content in their SDS, and one study which reported D4 content in cleaning products. The two spray-on cleaning products had D4 content between 0.1 and 1 percent ([C.R. Laurence, 2019](#); [Spartan Chemicals, 2015](#)), while the spray-on fabric product contained D4 at 0.1 percent ([Faultless, 2019](#)). One study found D4 at concentrations below 1 percent in various household cleaning products purchased in the United States, though specific product types were not reported ([Horii and Kannan, 2008](#)). Since the D4 weight fractions identified in SDS and literature were lower than the range reported by ACC SEHSC, EPA used the ACC SEHSC values as a conservative estimate. The ACC supplied concentration range was used in low, medium, and high exposure scenarios (1 percent, 3 percent, and 5 percent). These products are under the two subcategories that cover (1) cleaning and furnishing care products and (2) fabric, textile, and leather products not covered elsewhere. They will be referred to as cleaning products hereafter. Cleaning products were modeled for inhalation and dermal exposures resulting from contact during use.

For consumer laundry detergent, EPA was unable to identify any information specifying D4 content but did find evidence of its presence. Tide (brand) reported that siloxane and silicones are used in their products to suppress foam formation in a washer ([P&G, 2025](#)). An SDS from a producer of antifoaming agents ([Dow Chemical, 2022](#)) recommends adding 0.1 to 0.5 percent of its agent to detergent. Dowsil ([2022](#)) also indicated the presence of a polymer called polydimethylsiloxane (PDMS). There are multiple types of PDMS polymers, and the D4 content varies for each one. The PDMS used by Dowsil is produced by a separate company and reported to contain up to 3 percent D4 ([Gelest, 2025](#)). Together, this information can be used to estimate a weight fraction of D4 in laundry detergent but was not applied in that manner. That is because of likely variations in the formulation of detergent, which includes the particular type and percentage of D4 content in the antifoaming agent. EPA instead used an ACC SEHSC submission that stated the majority of washing and cleaning products contains 1 to 5 percent D4 ([Exponent, 2024](#)). The weight fractions for the low-, medium-, and high-intensity use scenarios were 1 percent, 3 percent, and 5 percent, respectively.

Consumer laundry detergent was modeled for only inhalation resulting from emission during wash. Dermal exposure was not evaluated because of likely negligible exposure when dispensing detergent into a washer. Potential dermal contact from handwashing of clothing is possible but not evaluated because of uncertainties in inputs for the scenario. It is unclear whether laundry detergent designed for a washing machine will be used for hand laundering, and if it is, how much of that will be diluted. Consumers are unlikely to immerse their hands in a basin containing only detergent, thus the dilution factor is an important consideration otherwise the dermal loading of D4 will be overestimated. It is also unclear how frequent hand laundering occurs or how many garments are washed each time. These consumer patterns are needed to inform the use frequency and exposure duration, respectively. Without information on these parameters, EPA is unable to develop an exposure scenario for hand laundering that is representative for a national level assessment and does not contain a high level of uncertainty.

Paint and Lacquer Products

A total of five paint and lacquer products were identified and modeled for inhalation and dermal exposures. The products were split into two groups for modeling to capture differences in expected use patterns. The first group contains three products for stone, masonry, and wood waterproofing were identified with D4 content. Based on manufacturer specifications and consumer reviews on retailer websites, these products are expected to be used for refinishing outdoor surfaces with large surface areas. All specified that they could be brushed, rolled, or sprayed on. The D4 content reported in these products were 0.05 to 1 percent ([UGL, 2023](#)), 2.5 to 10 percent ([Rust-Oleum, 2023b](#)), and 15 to 20 percent ([Benjamin Moore, 2024](#)). Based on these data, the D4 weight fractions used in low, medium, and high exposure scenarios were 0.05 percent, 8 percent, and 20 percent. The weight fraction for the medium scenario is the average of the weight fraction among all available SDSs.

The second group contains two products for wood and metal refinishing. Based on manufacturer specifications and consumer reviews on retailer websites, these products could be applied indoors and outdoors and are expected to be applied to items with small to medium surface areas. Both specified that they could be brushed, rolled, or sprayed on. The D4 content reported in these products were 7 to 13 percent ([Old Masters, 2020](#)) and 10 to 25 percent ([Rust-Oleum, 2023a](#)). Based on these data, the D4 weight fractions used in low, medium, and high exposure scenarios were 7 percent, 14 percent, and 25 percent. Paint and lacquer products were modeled for inhalation and dermal exposures resulting from contact during use.

Animal Grooming Products

Five animal grooming products with consumer uses containing D4 have been identified ([U.S. EPA, 2021](#)). Products include serums, finishing sprays, and conditioners for various animals such as horses, dogs, and cats. However, EPA could not identify any SDS sheets specifying D4 content. The only data source reporting D4 content in these animal grooming products was ACC SEHSC ([Exponent, 2024](#)). These products were reported to contain up to five percent of D4, with the majority in the range of 1 to 5 percent. As such, EPA assessed at the provided weight fractions of 1 percent, 3 percent, and 5 percent for use in the low, medium, and high exposure scenarios. ACC SEHSC also indicated that animal grooming products have the potential to generate aerosols. Animal grooming products were thus modeled for inhalation in addition to dermal exposures resulting from contact during use.

596 **Table 2-1. Summary of Consumer COUs, Exposure Scenarios, and Exposure Routes**

Consumer Use Category	Consumer Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes				
				Inhalation ^a	Dermal	Ingestion		
						Dust (Air)	Dust (Surface)	Mouthing
Adhesives and sealants	Adhesives and sealants	Caulking compounds	Application of product in house; direct contact during use; inhalation of emissions during use	QT	QT	QL	QL	QL
Automotive care products	Automotive care products	Exterior car wax and tire dressing sprays	Application of product in house (garage) via spray; direct contact during use; inhalation of emissions during use	QT	QT	QL	QL	QL
Furnishing, cleaning, treatment/care products	Cleaning and furnishing care products	Cleaning sprays	Application of product in house via spray; direct contact during use; inhalation of emissions during use	QT	QT	QL	QL	QL
	Fabric, textile, and leather products not covered elsewhere	Spray sizing	Application of product in house via spray; direct contact during use; inhalation of emissions during use	QT	QT	QL	QL	QL
	Laundry and dishwashing products	Laundry detergent	Inhalation of emissions during use	QT	QL	QL	QL	QL
Other	Animal grooming products	Pet grooming sprays	Application of product in house via spray; direct contact during use; inhalation of emissions during use	QT	QT	QL	QL	QL
Packaging, paper, plastic, hobby products	Plastic and rubber products not covered elsewhere	Plastic and rubber articles meant to be mouthed (nipples, pacifiers, toothbrushes)	Ingestion by mouthing.	QL	QL	QL	QL	QT
		Rubber shoe components	Direct contact during wear	QL	QT	QL	QL	QL
	Toys, playground, and	Rubber and plastic toys	Direct contact during use;	QL	QT	QL	QL	QT

PUBLIC RELEASE DRAFT
September 2025

Consumer Use Category	Consumer Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes				
				Inhalation ^a	Dermal	Ingestion		
						Dust (Air)	Dust (Surface)	Mouthing
	sporting equipment		ingestion by mouthing					
	Toys, playground, and sporting equipment	Putties and other viscoelastic polymer toys	Direct contact during use	QL	QT	QL	QL	QL
Paints and coatings	Paints and coatings	Paint and lacquer spray (small, indoor projects)	Application of product in house (garage) via spray; direct contact during use; inhalation of emissions during use	QT	QT	QL	QL	QL
		Paint and lacquer spray (large, outdoor projects)	Application of product outdoors via spray; direct contact during use; inhalation of emissions during use	QT	QT	QL	QL	QL
Textiles and apparel	Textiles and apparel	Bedding	Direct contact during use; inhalation of emissions.	QT	QT	QL	QL	QL
		Clothing	Direct contact during use	QL	QT	QL	QL	QL
		Fabric and textile toys ^b	Direct contact during use; ingestion by mouthing	QL	QT	QL	QL	QT
Working fluids	Brake fluid	Analysis of these consumer COUs were conducted by linking with commercial use scenarios, as described in Section 2.1.3.						
Polyurethane foam	Polyurethane foam							
Oil and gas products	Diesel fuel additive							
Disposal	Disposal	Down-the-drain of products and disposal of articles	Down-the-drain and releases to environmental media	QL	QL	QL	QL	QL
QT = quantitative consideration; QL = qualitative consideration Exposure by route was deemed unlikely because of physicochemical characteristics of D4 and/or expected use patterns, such as likely negligible gas to dust partitioning low possibility of mouthing based on product use patterns, and low possibility of significant exposure via inhalation due to small surface area of emissions. ^a Although D4 in air is expected to primarily exist as a vapor because of D4's high volatility, CEM does not differentiate between air concentrations of D4 in the vapor or aerosol form.								

Consumer Use Category	Consumer Use Subcategory	Product/Article	Exposure Scenario and Route	Evaluated Routes				
				Inhalation ^a	Dermal	Ingestion		
						Dust (Air)	Dust (Surface)	Mouthing
^b Some products under the textile and apparel COU were textile- and fabric-based toys (<i>e.g.</i> , stuffed animals). Inhalation exposure was not evaluated because of the small surface area for D4 emissions. Dermal exposure to textile and fabric toys are evaluated together with clothing. It is expected to be more protective because of the larger exposed skin surface area from wearing clothing than playing with toys. Oral exposure to D4 is possible and important to consider for textile and fabric toys because of the mouthing potential among children. Therefore, textile and fabric toys were isolated from the textile and apparel COU for the ingestion exposure scenarios.								

597

2.1.3 Linkages to Occupational Exposure Scenarios

The *Draft Environmental Release and Occupational Exposure Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025e](#)) details one OES intended to capture exposure for ten industrial and/or commercial COUs (Table 2-2). Products under these COUs are expected to contain D4 at less than 5 percent by weight ([SEHSC, 2020](#)), and in many cases, much less. Because silicone polymer mixtures, such as PDMS, are used in a broad range of products and commercial and/or industrial sectors, it is difficult to analyze every single use ([Brooke et al., 2009](#)). EPA therefore analyzed occupational exposures to all ten COUs using (1) cleaning and furnishing care products and (2) laundry and dishwashing products. These two COU subcategories were selected because they are expected to result in the greatest exposure potential to D4 for workers using products containing D4 at residual levels.

Table 2-2. Use of Residual D4-Containing Products OES to Industrial and/or Commercial COUs Crosswalk.

COU			OES ^b
Life Cycle Stage ^a	Category	Subcategory	
Industrial and/or commercial uses	Furnishing, cleaning, treatment/care products	Cleaning and furnishing care products	Use of residual D4-containing products
		Fabric, textile, and leather products not covered elsewhere	
		Laundry and dishwashing products	
	Lubricant and greases	Lubricants and greases	
	Working fluids	Working fluids (e.g., hydraulic, heat transfer, and other fluids used in gauges, pumps, and other equipment)	
	Release agents	Release agents (e.g., in wood product manufacturing)	
	Polyurethane foam (additive)	Polyurethane foam (e.g., construction)	
	Oil and gas products	Oil and gas products	
	Ink, toner, and colorant products	Ink, toner, and colorant products	
	Plastic and rubber products not covered elsewhere	Plastic and rubber products not covered elsewhere	

^a Life Cycle Stage use (40 CFR 711.3)

- “Industrial use” means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed.
- “Commercial use” means the use of a chemical or mixture containing a chemical (including as part of an article) in a commercial enterprise providing saleable goods or services.
- Although EPA has identified both industrial and commercial uses here for purposes of distinguishing scenarios in this document, the Agency interprets the authority over “any manner of method of commercial use” under TSCA section 6(a)(5) to reach both.

^b Circumstances on which SEHSC requested that EPA conduct a risk evaluation of D4.

Exposure estimates for four consumer COUs (Table 2-3) are represented by the Uses of residual D4-

containing products OES. The consumer COU for Lubricants and greases includes D4-containing products such as Sprayway® SW450 (Sprayway, 2020) and Molykote® (Dow Corning, 2022) at concentrations of less than 5 percent and less than 1 percent, respectively. Brake fluids include products with 95 percent PDMS (TCC, 2017), which contains up to 3 percent D4 according to a producer of PDMS (Gelest, 2025). Polyurethane foam may contain D4 at concentrations of 0.05 percent or less (U.S. EPA, 2025i). Finally, diesel fuel additives have a D4 content of 0.1 to less than 1 percent (Momentum, 2019). Data for these four consumer COUs demonstrate D4 at a residual concentration or D4 as a residual within a PDMS polymer. Because the D4 content in these consumer products are at similarly low concentrations as the commercial ones, EPA used the commercial analysis for these consumer COUs. Commercial uses of products in these COUs are expected to occur at higher levels than for consumers. For example, the use frequency for the OES is assumed to be 250 days per day, which is a conservative estimate for consumers who may only occasionally work with products represented by the aforementioned COUs. Furthermore, the industrial or commercial settings include janitorial services for buildings, appliance repair and maintenance, hotels, or hospitals. Usage of these products in these settings will likely be more intense than for consumer in or around their residence. Therefore, EPA expects the commercial scenarios to be protective of consumer uses.

Table 2-3. Consumer COUs Represented by Industrial and/or Commercial Uses of Residual D4 Containing Products OES

Life Cycle Stage	Category	Subcategory
Consumer use	Lubricants and greases	Lubricants and greases
	Working fluids	Brake fluid
	Polyurethane foam	Polyurethane foam
	Oil and gas products	Diesel fuel additive

2.2 Disposal COU

Environmental releases of D4 may occur via the end-of-life disposal and demolition of consumer products and articles in the built environment or landfills, as well as from the associated down-the-drain release of D4. It is difficult for EPA to quantify these ends-of-life and down-the-drain exposures due to limited information on source attribution of the consumer COUs. In previous assessments, EPA has considered down-the-drain analysis for consumer products where there are reasonably foreseen exposure scenarios of consumer product (e.g., paints, sealants) being discarded directly down-the-drain. For example, adhesives, sealants, paints, lacquers, and coatings can be disposed down-the-drain while users wash their hands, brushes, sponges, and other product applying tools. Consumer use of laundry detergent is another COU that can result in down-the-drain disposal of D4. However, EPA does not expect surface water to be a major compartment for D4. Much of D4 is expected to either volatilize or sorb to sludge during wastewater treatment. The mean removal efficiency of D4 from wastewater reported in three U.S. and Canadian studies is 94 percent (see the *Draft Physical Chemistry and Fate Assessment for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025g). D4 present in the effluent is expected to readily evaporate from water and moist soil into the atmosphere based on its log K_{AW} value of 2.69. D4 also does not appreciably partition to water due to its low water solubility (0.056 mg/L at 23 °C). Volatilization is expected to be the dominant pathway for D4 when released to water. In addition, D4 may hydrolyze to smaller, more polar products in water. Because D4 in surface water will volatilize or settle out of the water column via advection, dispersion, or sorption to organic matter, down-the-drain releases from consumer COUs was not further evaluated.

High quality monitoring data from the *D4 Environmental Testing Final Report* ([ERM, 2017a, b](#)) also provide evidence of very low D4 concentrations from down-the-drain releases. It was prepared in accordance with an Enforceable Consent Agreement (ECA) between EPA and five signatory companies (Dow Corning Corporation, Evonik Corporation, Momentive Performance Materials USA Inc., Shin-Etsu Silicones of America, Inc., and Wacker Chemical Corporation), and is hereafter referred to as the ECA. The ECA provides monitoring data from 14 wastewater treatment plants (WWTPs): four are onsite systems that treat wastewater from D4 manufacturing/processing (“DD”), five receive wastewater from industrial sites known to be D4 processors or formulators (“I”), and five receive less than 15 percent of wastewater from industrial facilities and preferably none from D4 manufacturers, processors, or formulators (“R”). The “I” and “R” sites represent potential D4 releases from consumers discarding D4-containing products down-the-drain because they receive domestic wastewater. Among them, “I5” serves the Greater Chicago area and 2.38 million people, which ranks it as not just the largest WWTP among the sampled sites but in the world.

ECA’s monitoring data demonstrate low surface water and sediment concentrations from samples collected from the well-mixed zone of the WWTP outfall. As expected, “I5” had some of the highest measured concentrations because it is the largest WWTP in the world and receives a mix of domestic, industrial, and commercial wastes. Mean D4 concentrations in surface water still do not exceed 0.04 µg/L (from “I5”) across all sampled facilities. All of the surface water samples from “I5” also had values below the laboratory method reporting limit of 0.076 µg/L. For sediment, mean concentrations are all below 5.7×10^{-3} mg/kg. Table 2-4 summarizes the mean D4 concentrations in surface water and sediment concentrations across all WWTPs sampled in the ECA.

676 **Table 2-4. Summary of Mean Surface Water and Sediment Concentrations from All Sampled WWTPs in the ECA (ERM, 2017a, b)**

Facility Type	Site ID	Site Name and Location	D4 Surface Water Concentration (Mean [± SEM] µg/L)	# Of Water Samples with Estimated Values Below Laboratory MRL	D4 Sediment Concentration (Mean [± SEM] mg/kg)	# Of Sediment Samples with Estimated Values Below Laboratory MRL
Manufacturing or processing plants that discharge treated wastewater directly into the environment after on-site treatment (“DD”)	DD1	Wacker Chemical Corporation, Adrian, MI	0.051 (± 0.02)	8/10	2.169 (± 0.59) ^b	7/10
	DD2	Dow Corning Corporation, Carrollton, KY	0.23 (± 0.06)	5/10	0.038 (± 0.01)	0/10
	DD3	MPM Silicones, LLC, Friendly, WV	0.33 (± 0.08)	1/10	0.114 (± 0.04)	0/10
	DD4	MPM Silicones, LLC, Waterford, NY	0.057 (± 0.01)	8/10	9.19 (± 0.32) ^b	10/10
WWTPs receiving wastewater for treatment from one or more industrial site known to be a D4 processor or formulator (“I”)	I1	Iowa City, IA	0.02 (± 0.003) ^c	10/10	2.4E–04 ^c	10/10
	I2	Columbus, OH	0.02 (± 0.003) ^c	10/10	5.70E–03	0/10
	I3	Wichita, KS	0.004 (± 0.001) ^c	10/10	6.90E–05 ^c	10/10
	I4	Gresham, OR	0.018 (± 0.006) ^c	10/10	N/A ^d	10/10
	I5	Chicago, IL	0.04 (± 0.004)	10/10	1.30E–03 ^c	8/10
WWTPs receiving <15% of wastewater for treatment from industrial facilities that are not D4 manufacturers, processors, or formulators (“R”)	R1	Steamboat Springs, CO	N/A ^d	10/10	N/A ^d	10/10
	R2	Boulder, CO	8.0E–06 ^c	10/10	1.6E–03 ^c	9/10
	R4	Lexington, KY	2.30E–05 ^c	10/10	2.00E–03	7/10
	R5	Genesee, MI	1.20E–04 ^c	5/10	N/A ^d	10/10
	R6	Elmhurst, IL	3.30E–05 ^c	9/10	5.30E–03	0/10
SEM = Standard error of the mean; MRL = Method reporting limit ^a MRL for water = 0.076 µg/L. MRL for sediment = 2.6E–03 mg/kg. ^b D4 sediment concentrations for DD1 and DD4 are presented as estimated values above the calibration range. ^c Mean D4 concentration is below the laboratory method detection limit for sediment (1.9E–03 mg/kg) or surface water (0.02 µg/L). ^d Estimated values for D4 concentrations were below zero.						

677

In addition to down-the-drain releases, D4-containing products can be disposed and taken to landfills when users no longer need them, or the products have reached the product shelf life. All other solid products and articles in Table 2-1 can be disposed in landfills or other waste handling locations that properly manage the disposal of products like adhesives, sealants, paints, lacquers, and coatings. However, no studies were identified which reported the concentration of D4 in landfills or in the surrounding areas in the U.S. (see Section 3.2 of the *Draft Environmental Media and General Population Exposure for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025d](#))). High-quality physical and chemical property data suggest that D4 is unlikely to be present in landfill leachate at high levels due to its low water solubility, strong affinity for sorption in soils, and high vapor pressure.

2.3 Modeling Inhalation of D4 Emitted from Liquid and Paste Products

The CEM Version 3.2 ([U.S. EPA, 2023](#)) was selected to model consumer inhalation exposures to D4 in liquid and paste products. The advantages of using CEM to assess exposures to consumers and bystanders are as follows:

- CEM model has been peer reviewed ([ERG, 2016](#));
- CEM accommodates the distinct inputs available for the products containing D4, such as weight fractions, product density, room of use, and frequency and duration of use (see Section 2.3.1 for product scenario inputs); and
- CEM allows for calculation of inhalation exposure for product users in close proximity to products.

CEM has capabilities to model inhalation exposure to D4 from both products and articles containing the chemical. However, CEM was only used to assess products because its assumptions were inappropriate for modeling emissions of VOCs like D4 from articles. For example, CEM considers emissions from solid articles as limited by the chemical's ability to partition from the solid material to air (K_{ma}), which is accurate for SVOCs that have a relatively low emission rate. Chemical concentrations in the solid matrix are assumed to be uniform and constant over time because of that low K_{ma} . This results in a scenario where the consumer article becomes an infinite source of the SVOC. VOCs emissions to air from a consumer article, on the other hand, is limited by the chemical's diffusion through the solid matrix. However, CEM does not consider this movement through the solid material. CEM assumes the chemical is immediately released from the article without factoring in the delay effect from the diffusion-limited scenario. CEM's assumption of an infinite source is also not appropriate for VOCs because the volatility will likely result in decreases in concentration over time. EPA did not use CEM to model air concentrations from solid articles for VOCs like D4 and considered IECCU more applicable. Further discussion of IECCU is presented in Section 2.4.

CEM 3.2 generates exposure estimates based on user-provided input parameters and various assumptions (or defaults). The model contains a variety of pre-populated scenarios for specific product and article categories and allows the user to define custom scenarios in instances where the prepopulated scenarios are not adequate. User inputs for physical and chemical properties are used to calculate emission profiles of SVOCs. There are six emission calculation profiles for products within CEM (E1 to E5) that represent specific use conditions and properties of various products. A description of these models is summarized in the CEM user guide and associated appendices ([U.S. EPA, 2023](#)).

CEM 3.2 calculates an air concentration (C_{air}) based on the average concentration in each room of use over the exposure duration of interest and the amount of time spent in each room. Acute exposures are for an exposure duration of one day, and chronic exposures are for an exposure duration of one year. EPA made some adjustments to match CEM's lifestyles to those listed in the Center for Disease Control

and Prevention (CDC) guidelines ([CDC, 2021](#)) and EPA's *A Framework for Assessing Health Risks of Exposures to Children* ([U.S. EPA, 2006](#)). CEM lifestages are re-labeled from this point forward as follows:

- Adult (21+ years) → Adult
- Youth 2 (16–20 years) → Teenager and young adult
- Youth 1 (11–15 years) → Young teen
- Child 2 (6–10 years) → Middle childhood
- Child 1 (3–5 years) → Preschooler
- Infant 2 (1–2 years) → Toddler
- Infant 1 (<1 year) → Infant

Age specific exposure factor inputs for these lifestages are provided in the EPA's CEM Version 3.2 Appendices ([U.S. EPA, 2023](#)).

2.3.1 Selected CEM 3.2 Models

The embedded models within CEM 3.2 that were used to model D4 exposure from inhalation of emissions from liquid and paste products are listed in Table 2-5. As dermal and oral exposure was modeled separately, only inhalation was evaluated in CEM.

Table 2-5. CEM 3.2 Model Codes and Descriptions Used to Model D4

Model Code	Description
E1	Emission from product applied to a surface indoors incremental source model
E3	Emission from product sprayed
E4	Emission from product added to water
P_INH1	Inhalation of product used in environment
P_INH2	Inhalation of product used in an environment (Near Field is used for users)

Table 2-6 presents a crosswalk between the COU subcategories with either a predefined or generic model scenario. Models were generated to reflect specific use conditions identified. In some cases, one COU mapped to multiple scenarios, and in other cases one scenario mapped to multiple COUs. Table 2-6 provides data on emissions model and exposure pathways modeled for each product scenario. Emissions models were selected based upon physical and chemical properties of the product and application use methods for products.

Table 2-6. Crosswalk of COUs, CEM 3.2 Scenarios, and Relevant CEM 3.2 Models Used for Consumer Modeling

Consumer COU Category	Consumer COU Subcategory	Product Modeled	Scenario Name, Pathway Model, and CEM Emission Model
Adhesives and sealants	Adhesives and sealants	Caulking compounds	Caulking Compounds, E1, P_INH2
Automotive care products	Automotive care products	Exterior car wax and tire dressing sprays	Auto Care Products, E3, P_INH2

Consumer COU Category	Consumer COU Subcategory	Product Modeled	Scenario Name, Pathway Model, and CEM Emission Model
Furnishing, cleaning, treatment/care products	Cleaning and furnishing care products	Cleaning sprays	Cleaning Products, E3, P_INH2
	Fabric, textile, and leather products not covered elsewhere	Spray sizing	Cleaning Products, E3, P_INH2
	Laundry and dishwashing products	Laundry detergent	Cleaning Products, E4, P_INH1
Other	Animal grooming products	Pet grooming sprays	Pet Care Products, E3, P_INH2
Paints and coatings	Paints and coatings	Paint and lacquers for small indoor projects	Paints and Lacquers (small project), E3, P_INH2
		Paint and lacquers for large outdoor projects	Paints and Lacquers (large project), E3, P_INH2

In total, the specific products representing five COUs categories and seven subcategories were mapped to seven scenarios. Relevant consumer behavioral pattern data (i.e., use patterns) and product-specific characteristics were applied to each of the scenarios and are summarized in Section 2.3.2.

2.3.2 Modeling Inputs and Parameterization

CEM's estimated emission rates are used in a deterministic mass balance model to calculate indoor air concentrations. CEM 3.2 uses a two-zone representation of the building of use when predicting indoor air concentrations. Zone 1 corresponds to the room where the product is used, while Zone 2 represents the remainder of the building. Each zone is assumed to be well-mixed. The model allows for further division of Zone 1 into a near field and far-field to accommodate situations where a higher concentration of product is expected very near the product user during the period of use. Zone 1 near-field represents the breathing zone of the user at the location of the product use, while Zone 1 far-field represents the remainder of the Zone 1 room. The modeled concentrations in the two zones are a function of the time-varying emission rate in Zone 1, the volumes of Zones 1 and 2, the air flows between each zone and outdoor air, and the air flows between the two zones. Following product use, the user and bystander may follow one of three pre-defined activity patterns: full time employment outside the home, part time employment outside the home, and stay-at-home. The activity use pattern determines which zone is relevant for the user and bystander and the duration of the exposures. The user and bystander inhale airborne concentrations within these zones, which can vary over time, resulting in the overall estimated exposure for each individual. The stay-at-home activity pattern was selected for this assessment for all scenarios as the most conservative behavior pattern, with the option for further refinement should risk be identified. For the "Stay-at-Home" activity pattern used in these analyses, both users and bystanders are assumed to be in the home for most of the day (20 hours).

CEM applies default air exchange rates for buildings from the EPA's *Exposure Factors Handbook* ([U.S. EPA, 2011b](#)). The default interzonal air flows are a function of the overall air exchange and volume of the building as well as the openness of the room, which is characterized in a regression approach for closed rooms and open rooms ([U.S. EPA, 2023](#)). More open rooms (e.g., kitchens, living rooms, garages) have an interzonal ventilation rate of 109 m³/hour, while more enclosed rooms (e.g., bedrooms, bathrooms, laundry rooms) have a rate of 107 m³/hour. In instances where the whole house is selected as

the room of use, the entire building is considered zone 1, and the interzonal ventilation rate is therefore equal to the negligible value of $1 \times 10^{-30} \text{ m}^3/\text{hour}$. In instances where a product might be used in several rooms of the house, air exchange rate was considered in the room of use to ensure that effects of ventilation were captured.

Higher concentrations of D4 in air will result in increased inhalation exposure. This may occur due to product formulation or use patterns that allow for higher emissions of D4 to air and/or environment specific characteristics such as smaller room volume and lower ventilation rates. Key parameters that control D4 emission rates from products in CEM 3.2 models are weight fraction of D4 in the formulation, duration of product use, mass of product used, and frequency of use. Any increase in these parameters will result in higher chemical exposure from product use.

Low, medium, and high default values in pre-populated CEM scenarios were used for duration of product use, mass of product used, and frequency of use when the product identified was a reasonably close match. In instances where a D4 containing product did not have an adequately similar CEM pre-populated scenario, values were estimated based on data from the *Exposure Factors Handbook*. Product densities were taken from product specific technical specification when possible. In instances where no data were available for a product type, a density obtained for a similar product was used. CEM default values for environmental parameters (room volume, ventilation rates, etc.) were applied based on the room of expected use. In instances where a product could be used in more than one location, room volume, ventilation rates, and behavioral patterns were considered to select the room of use expected to provide the most health protective estimate. A detailed description of key parameter derivation is provided below, and a summary of values can be found in Table 2-7.

Adhesives and Sealants for Home DIY Projects

For adhesive and sealant compounds, default values from the “Caulk (sealant)” scenario in CEM were considered for use but deemed inappropriate. This scenario is designed for general-purpose caulking products, whereas the identified products containing D4 were specialized (*e.g.*, high heat, chemical, and weather resistance) and therefore expected to have more limited use.

Instead, product mass used and duration of use were assumed to be half the default values for general-purpose caulking products in the CEM “Caulk (sealant)” scenario. This adjustment reflects the expectation that these specialized products are not appropriate for use in large-scale, whole-home applications and aligns with consumer product reviews on vendor websites, which indicate a range of usage patterns for small, medium, and somewhat large projects. The mass of product used was assumed to be 37.5 g, 75 g, and 200 g in low, medium, and high exposure scenarios based on a combination of professional judgment and consumer product reviews. The assumed duration of use was 30 minutes, 60 minutes, and 120 minutes for low, medium, and high exposure scenarios. Use frequency was set at three times per year, consistent with the CEM default value, which again reflects the fact that these products have fewer potential applications than general-purpose caulking compounds. CEM did not provide different use frequencies that can be incorporated into the different intensity use scenarios. Therefore, only one value was used for the low, medium, and high-intensity use scenarios.

Automotive Care Products

The auto care products identified with D4 content included spray wax and tire dressing products that are designed for exterior car care. CEM does not have a prepopulated or predefined model that is applicable to exterior car care products, and the *Exposure Factors Handbook* did not provide relevant data for EPA to build a separate CEM model scenario. However, the CEM defaults for duration of use and mass of product applied under the “Interior car care cleaning and maintenance products” scenario were expected

to be similar as exterior car products. This conclusion is based on professional judgment informed by the product descriptions and consumer reviews on retailer websites. The CEM defaults for duration of use from “Interior car care cleaning and maintenance products” scenario are 10 minutes, 20 minutes, and 30 minutes in the low, medium, and high exposure scenarios. Mass of product used per event was modeled as 5 g, 10 g, and 40 g based on CEM defaults in low, medium, and high exposure scenarios. These products were expected to be used once per month, so were modeled at a use frequency of 12 times per year.

Cleaning Products

The cleaning products identified with D4 content included a clothing ironing spray and two products for adding shine to indoor surfaces or cleaning a variety of plastic materials. CEM default values from the “All-purpose spray cleaner” scenario were selected for duration of product and mass of product used. The duration of use was modeled as 5 minutes, 15 minutes, and 30 minutes in low, medium, and high exposure scenarios. Mass of product used per event was modeled as 10 g, 30 g, and 60 g based on CEM defaults in low, medium, and high exposure scenarios.

However, the default frequency of use in CEM’s “All-purpose spray cleaner” scenario ranges from 150 to 365 events per year, which reflects frequent, routine cleaning tasks. In contrast, the identified products are formulated for use in more specialized tasks (*e.g.*, shining and waterproofing indoor surfaces and ironing clothing) that are less likely to occur routinely. EPA determined that a frequency of 104 events per year (twice per week) is more reasonable based on professional judgment and Table 17-10 of the *Exposure Factors Handbook* ([U.S. EPA, 2011b](#)). Table 17-10 reports frequencies of various household tasks that includes routine activities and less routine ones such as cleaning cabinets, glass surfaces, or the exterior of kitchen appliances. The less routine activities had frequencies ranging from three to seven times per month and are more aligned with the purpose of the cleaning products containing D4. EPA determined a frequency of 104 events per year, which averages to about 8.7 times per month, because it reflects a conservative assumption to account for the fact that consumers may use the D4 products for multiple household tasks. An annual frequency of use at 104 events per year was used for this COU.

The use of these products for shining and waterproofing indoor surfaces among people who clean residences for a living is evaluated in the *Draft Environmental Release and Occupational Exposure Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025e](#)). The relevant commercial COU is also Furnishing, cleaning, treatment/care products, and the OES is the Use of residual D4-containing products. The product intended for crisping up clothing while ironing does not have a corresponding commercial COU, though.

Laundry Detergent

Two of CEM’s prepopulated scenarios, “Laundry detergent (liquid)” and “Laundry detergent (solid/granule),” were determined to be a match for this consumer product of interest. As such, the CEM defaults for the duration of product use, mass of product used, and frequency use were incorporated into this analysis. These values were the same across both prepopulated scenarios. For the high-, medium-, and low-intensity use, the duration of use is 50, 45, and 40 minutes per event, respectively. The mass used per event is 60, 40, and 20 g per event. The frequency of use is 365, 300, and 185 events per year which was relevant for estimating chronic exposure. The frequency of use for acute or daily exposure is 3 events. These default values are sourced from the *Exposure Factors Handbook* or other peer-reviewed publications and can be found in U.S. EPA ([2023](#)).

Paint, Lacquer, and Surface Coating Products

For paint and lacquer products used in large outdoor projects, exposure-related parameters were based on consumer use of finishing and sealing products on outdoor surfaces, as reported in the *Exposure Factors Handbook* (U.S. EPA, 2011b). Table 17-4 of the *Exposure Factors Handbook* provides a use frequency of three times per year for outdoor water repellents applied to wood or cement based on higher-end users (90th percentile). Table 17-5 reports a duration of use ranging from 15 minutes (10th percentile to 240 minutes (90th percentile). Accordingly, exposure durations of 15, 128, and 240 minutes were assigned to low, medium, and high exposure scenarios, respectively.

The amount of product used per year is provided in Table 17-6 of the *Exposure Factors Handbook*, with reported values ranging from 8 oz (~ 237 cm³, 10th percentile) to 448 oz (~13,261 cm³, 90th percentile). Using the average reported product density of 1.79 g/cm³, the estimated mass of product used per year ranged from 424 to 23,671 g. It was assumed that this annual mass was evenly distributed across three use events, resulting in estimated per-use masses of 141 g (low exposure) and 7,890 g (high exposure), with the medium exposure scenario using the average of the two (4,016 g).

For paint and lacquer products used in smaller projects with potential indoor use, exposure-related parameters were based on consumer use of paint and lacquer products as reported in the *Exposure Factors Handbook* (U.S. EPA, 2011b). Table 17-4 provides a use frequency of seven times per year for wood stains, varnishes, and finishes in higher-end users (90th percentile). The duration of use, according to Table 17-5, ranges from 10 minutes (10th percentile) to 140 minutes (90th percentile). The selected room of use was an indoor garage based on consumer reviews of where these products were commonly applied (e.g., garage door).

Table 17-6 reports that the amount of product used per year ranges from 4 oz (~118 cm³, 10th percentile) to 128 oz (~3,788 cm³, 90th percentile). Using an average density of 0.89 g/cm³, the estimated mass of product used per year ranges from 106 to 3,371 g. Assuming even distribution across the seven yearly use events, the estimated per-use masses were 15 g (low exposure) and 482 g (high exposure), with the medium-exposure scenario using the average of the two (249 g).

Animal Grooming Products

ACC SEHSC indicated that animal grooming products have the potential to generate aerosols. As such, animal grooming products were modeled as a spray product. No other data were available to estimate exposure-related parameters for consumer use, thus use patterns were estimated based on professional judgment after searching online databases and consumer reviews of relevant products. This assumed at once per week grooming session of 15 minutes, 30 minutes, and 45 minutes in low, medium, and high exposure scenarios. Mass of product used per event was modeled as 75 g, 100 g, and 125 g in low, medium, and high exposure scenarios.

918
919

Table 2-7. Summary of Key Parameters for Products Modeled in CEM 3.2

Product	Exposure Scenario Level	Weight Fraction (%)	Density (g/cm ³) ^a	Duration of Use (mins)	Product Mass Used (g)	Chronic Freq. of Use (year ⁻¹)	Acute Freq. of Use (day ⁻¹)	Use Environment Volume (m ³) ^{b c}	Air Exchange Rate, Zone 1 and Zone 2 (hour ⁻¹) ^{b d}	Interzone Ventilation Rate (m ³ /hr) ^d
Adhesives and sealants	High	3	1.07	120	200	3	1	Bathroom; 15	0.45	107
	Medium	0.07		60	75					
	Low	0.03		30	38					
Auto care	High	10	0.97	30	40	12	1	Garage; 90	0.45	109
	Medium	2.4		20	10					
	Low	0.05		10	5					
Cleaning products	High	5	1	30	60	104	1	Bathroom; 15	0.45	107
	Medium	3		15	30					
	Low	1		5	10					
Laundry detergent (liquid and solid)	High	5	0 ^d	50	60	365	3	Laundry room; 8	0.45	72.5
	Medium	3		45	40	300				
	Low	1		40	20	250				
Paint and lacquer (large project)	High	20	1.79	240	7890	3	1	Outside; 492	0.45	1E-30
	Medium	8		128	4016					
	Low	0.05		15	141					
Paint and lacquer (small project)	High	25	0.89	140	482	7	1	Garage; 90	0.45	109
	Medium	14		75	248					
	Low	7		10	15					

PUBLIC RELEASE DRAFT
September 2025

Product	Exposure Scenario Level	Weight Fraction (%)	Density (g/cm ³) ^a	Duration of Use (mins)	Product Mass Used (g)	Chronic Freq. of Use (year ⁻¹)	Acute Freq. of Use (day ⁻¹)	Use Environment Volume (m ³) ^{b c}	Air Exchange Rate, Zone 1 and Zone 2 (hour ⁻¹) ^{b d}	Interzone Ventilation Rate (m ³ /hr) ^d
Pet care	High	5	1	30	60	52	1	Bathroom; 15	0.45	107
	Medium	3		15	30					
	Low	1		5	10					

^a Density values provided in *Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025b](#))

^b For all scenarios, the near-field modeling option was selected to account for a small personal breathing zone around the user during product use in which concentrations are higher, rather than employing a single well-mixed room. A near-field volume of 1 m³ was selected.

^c Use environment corresponds to indoor room or location of use determined from specific product manufacturer use description.

^d CEM default

920

2.4 Modeling Inhalation of D4 Emitted from Solid Articles

The IECCU Version 1.1 ([U.S. EPA, 2019](#)) was selected to model consumer inhalation exposures to D4 in solid articles. It is a peer-reviewed model that relies on user-provided input parameters (*e.g.*, solid-air partitioning coefficients, solid phase diffusion coefficients, environment volume and air flow rates) and various assumptions (*e.g.*, article is able to emit freely to air, air is well mixed, ventilation rates are constant) to generate exposure estimates. IECCU has emissions equations that are appropriate for VOCs which could be parameterized with the data available for the articles containing D4. The environmental parameters such as building and room volumes, air flow, and ventilation rates in IECCU are adjustable and can be calibrated to align with those of CEM, ensuring consistent environmental conditions across both models for inhalation exposure assessment. Additional information about IECCU is available in the user guide ([U.S. EPA, 2019](#)).

Emissions of D4 from solid articles were modeled with a diffusion-based model. The model incorporates key physical and chemical properties (*e.g.*, diffusion coefficient, partition coefficient, and vapor pressure) that regulate chemical transport within the solid matrix and its partitioning to air, both of which influence the overall emission rate ([U.S. EPA, 2019](#)).

The calculated emission rates are then used in a deterministic, mass balance calculation of indoor air concentrations. IECCU can be configured with one, two, or three zones within a building. To match the conditions used in CEM, articles modeled in a whole home used a single zone configuration while articles modeled in a single room used a two-zone configuration. There is no distinction made between user and bystander nor is there a near-field selection as in product models. IECCU has preconfigured models for environmental inputs including building volumes, ventilation rates, and interzonal air flows, but the default values for these inputs were not used in this assessment. Instead, these conditions were matched to conditions used in CEM for single room or whole house scenarios to ensure that calculations were consistent across models.

IECCU reports air concentrations in each zone for the entire modeling period. These values are then used to calculate an exposure concentration in air (C_{air}) for each age group based on the average concentration in each zone over the exposure duration of interest and the amount of time spent in each zone. Movement patterns used to calculate time spent in each zone were assumed to be the same as those used in CEM. In addition, acute and chronic inhalation doses were calculated for each of the age groups as described in Section 2.2; once again, the inhalation rates and body weight values used were the same as those used in CEM to ensure consistency in analysis. Equations for inhalation dose calculations are shown in Appendix A.

2.4.1 Modeling Inputs and Parameterization

Higher concentrations of D4 in air will result in increased inhalation exposure. This may occur due to article specific characteristics that allow for higher emissions of D4 to air. Key parameters that control modeled D4 emission rates from articles are weight fraction of D4 in the material, article surface area (m^2), surface layer thickness (cm), solid phase diffusion coefficient (m^2/s), and the solid-air partitioning coefficient (unitless). An increase in any of these parameters, except the solid-air partitioning coefficient, will result in increased emissions and greater exposure to D4. In the case of the solid-air partitioning coefficient, a decrease will result in higher emission rates and increased exposure to D4. Environment specific characteristics such as a smaller room volume and lower ventilation rate will also increase D4 concentrations in air.

The majority of the solid articles identified with D4 content had very low weight fractions and surface

area, which would be expected to result in negligible inhalation exposure once emissions are dispersed within a room or building volume. However, in the case of fabric and textile items, a large item of bedding may have sufficient surface area to result in significant exposure from inhalation despite the low concentration. As such, only bedding that has surface areas much greater than 1 m² was modeled for inhalation exposure among the solid articles.

Weight fractions used for bedding were calculated as outlined in Section 2.1.1. The starting concentration of D4 in the bedding was assumed to be constant throughout the material. Surface area of bedding was estimated assuming one king sized blanket using a standard surface area of 275 cm by 250 cm, which was approximated based on items for sale across multiple e-commerce vendors. When both sides of the blanket are considered, the resulting surface area included in the model was 13.75 m². The surface layer thickness was specified at 0.001 m.

For the solid phase diffusion coefficient, a material-specific value was estimated with a quantitative property-property relationship (QPPR) that predicts diffusion coefficients for a wide range of organic chemicals and materials based on temperature, material type, and molecular weight of the chemical (Huang et al., 2017). This model was internally and externally validated against measured diffusion coefficients and shown to have good predictive capability for chemicals with molecular weights between 30 and 1,178 g/mol at temperatures between 4 and 180°C. D4 has a molecular weight of 296.616 g/mol. Since there were no available data for diffusion through fabric, the parameters for synthetic carpet fibers were used as this was considered the closest material modeled. The value calculated and used to assess inhalation exposure from bedding was 5.79 x 10⁻¹⁰ m²/hour. Full calculations for these values can be found in the supplemental *Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025b).

The solid-air partitioning coefficient was estimated with a quantitative structure-property relationship (QSPR) that predicts partitioning coefficients for a large number of chemicals and materials based on the octanol/air partitioning coefficient (log K_{OA}), enthalpy of vaporization, material type, and temperature (Huang and Jolliet, 2019). This model was internally and externally validated and shown to have good predictive capability for chemicals with log K_{OA} from 1.4 to 14.6, enthalpy of vaporization from 22.3 to 75.6 kJ/mol, and temperatures from 15 to 100°C. Physical and chemical properties used to estimate the solid phase diffusion coefficient and solid air partitioning coefficient may be found in the *Draft Physical Chemistry and Fate Assessment for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025g) with the exception of the enthalpy of vaporization. An estimated value for enthalpy of vaporization was obtained from an online database called ChemSpider (RSC, 2020). The calculated solid-air partition coefficient used to assess inhalation exposure from bedding was 9.01×10³. Full calculations for these values can be found in *Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025b).

Environmental factors were specified to match the CEM input values for bedroom. This included a zone one volume of 36 m³, zone two volume of 456 m³, and interzonal air flow rate of 0.45 m³ per hour. In addition, behavioral patterns that were used to calculate a dose were specified to match CEM inputs.

2.5 Dermal Modeling Approach

Dermal doses of D4 were estimated from contact with liquid, paste, and solid products; however, the calculated doses are potential rather than absorbed doses. Potential dose is the amount of contaminant on the skin and not expected to be fully absorbed. This approach was taken because the benchmark dose (BMD) values used to characterize risk were derived from a physiologically based pharmacokinetic (PBPK) model that linked external doses to observed effects. Since the PBPK model already accounts

for absorption and internal distribution, incorporating absorption into the dose calculations would have been redundant. Therefore, dermal exposures to D4 resulting from contact with both liquid products and solid articles were modeled using equations that estimate the surface loading of D4 on the skin outside of CEM. The underlying equations (see below in Section 2.5.1) for estimating dermal loading in this assessment were still the same as those in CEM. For details on BMD derivation, see *Draft Human Health Hazard Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025f](#)).

The PBPK model also estimated a dermal human equivalent dose (HED) appropriate for unoccluded conditions, when the skin is exposed to the environment and not covered by a barrier like clothing ([U.S. EPA, 2025f](#)). However, D4-containing solid articles can create an occluded situation where the article (e.g., bedding and clothing) covers the skin and act as a barrier for evaporation. As such, the PBPK model's dermal HED for unoccluded conditions was adjusted to reflect to occluded scenarios as explained in *Draft Human Health Hazard Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025f](#)). The next sections describe the methods for estimating dermal doses received per exposure event, including key equations and inputs. Equations for chronic, acute, and intermediate dermal dose calculations for both liquid and paste products and solid articles can be found in Appendix A.

2.5.1 Dermal Dose Modeling for Liquid and Paste Products

For all liquid and paste products, EPA assumed that inadvertent contact during product use results in exposure, because their descriptions do not include instructions requiring deliberate contact, such as hand mixing prior to application. Based on expected use conditions of the identified products, a thin-film model was used to estimate the potential dermal dose of D4 for each contact event assuming an unoccluded, finite-dose scenario as follows ([U.S. EPA, 2007](#)):

Equation 2-1. Potential Dermal Dose from Liquid Products per Exposure Event

$$PD_{liq} = Q_u \times f_{abs} \times SA$$

Where:

PD_{liq}	=	Potential dermal event dose (mg/event)
Q_u	=	Dermal loading (mg/cm ² -event)
f_{abs}	=	Fractional absorption (set to 1 for all products)
SA	=	Area of contact (cm ²)

Equation 2-2. Dermal Loading on Skin for Liquid Products

$$Q_u = FT \times \rho \times WF \times CF_1$$

Where:

Q_u	=	Dermal loading on skin (mg/cm ²)
FT	=	Film thickness on skin (cm)
ρ	=	Density of product (g/cm ³)
WF	=	Weight fraction of D4 in product (g D4/g product)
CF_1	=	Conversion factor (1,000 mg/g)

Consumer use is difficult to predict and is a significant source of uncertainty in this analysis, thus the most health protective values for film thickness of liquids on skin were chosen. To estimate film thickness after initial contact with liquid and assuming no wiping, data were obtained from Table 7-24

in the *Exposure Factors Handbook* ([U.S. EPA, 2011b](#)). This table also provides film thickness data for other experimental conditions including products which are wiped away, applied with a rag, or spilled and cleaned up. While these conditions may represent use patterns for these products, the values chosen for this analysis were the highest among the potentially relevant use scenarios. The data in the table were limited and did not have exact matches for all products but were matched with the closest product in terms of density and viscosity. Surface loading (mg/cm²) was then calculated using the product of D4 weight fraction, product density, and film thickness.

To calculate acute and chronic doses, skin contact areas were selected based on professional judgment, considering product use descriptions from manufacturers and each product's typical use. Skin contact areas are from CEM 3.2 For products which were considered to have a high level of uncertainty or variability, different surface areas in low, medium, and high scenarios were applied to determine reasonable contact areas for each product under different use conditions. Frequency of contact was assumed to be equal to the frequency of use (per year and per day) that was applied in CEM modeling. Values for all key parameters used to estimate dermal exposure are provided in Table 2-8. Calculations, data sources, input parameters and results are also available in *Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025b](#)).

Table 2-8. Key Parameters Used to Model Dermal Uptake from Liquid and Paste Products

Product	Exposure Level	Chronic Frequency (year ⁻¹) ^a	Acute Frequency (day ⁻¹) ^a	Film Thickness (cm) ^b	D4 Mass on Skin (mg/cm ²) ^c	Contact Area ^d
Adhesives and sealants	High	3	1	0.0159	5.08E-03	Inside of two hands (palms, fingers)
	Medium				1.24E-03	Inside of one hand (palms, fingers)
	Low				5.08E-05	10% of hands (some fingers)
Auto care	High	12	1	0.00325	3.14E-03	Inside of two hands (palms, fingers)
	Medium				7.54E-04	Inside of one hand (palms, fingers)
	Low				1.57E-05	10% of hands (some fingers)
Cleaning products	High	104	1	0.00325	1.63E-03	Inside of two hands (palms, fingers)
	Medium				9.75E-04	Inside of one hand (palms, fingers)
	Low				3.25E-04	10% of hands (some fingers)
Paint and lacquer (large project)	High	3	1	0.00981	3.50E-02	Inside of two hands (palms, fingers)
	Medium				1.42E-02	Inside of one hand (palms, fingers)
	Low				8.76E-05	10% of hands (some fingers)
Paint and lacquer (small project)	High	7	1	0.00981	2.18E-02	Inside of two hands (palms, fingers)
	Medium				1.20E-02	Inside of one hand (palms, fingers)
	Low				6.11E-03	10% of hands (some fingers)
Animal grooming	High	52	1	0.00325	1.63E-06	Inside of two hands (palms, fingers)
	Medium				9.75E-07	Inside of one hand (palms, fingers)
	Low				3.25E-07	10% of hands (some fingers)

^a Professional judgment using manufacturer product use descriptions to support decision making.
^b Input obtained from Table 7-24 in the *Exposure Factors Handbook* ([U.S. EPA, 2011b](#)).
^c Calculated parameter using Equation 2-2
^d Professional judgment based on product use description from manufactures.

2.5.2 Dermal Uptake Modeling for Contact with Solid Articles

Dermal absorption of D4 from solid articles was based on a simplified diffusion model ([Delmaar et al., 2013](#)), as used in CEM. This model calculates the dermal exposure using the migration of a chemical within an article to the skin via direct article contact.

Equation 2-3. Dermal Dose from Solid Articles per Exposure Event

$$PD_{art} = C_{art} \times \sqrt{2 \times D_p \times D_{art}} \times F_{abs_solids}$$

Where:

PD_{art}	=	Potential Dermal Event Dose (mg/event)
C_{art}	=	Chemical concentration in article (mg/cm ³)
D_p	=	Solid phase diffusion coefficient (cm ² /minutes)
D_{art}	=	Duration of article contact (minutes)
F_{abs_solids}	=	Fraction absorbed (unitless, assumed to be 1 for all articles)

Key parameters for estimating the potential dose of D4 from contact with solid items include the duration of dermal contact, frequency of dermal contact, and total contact area. An increase in any of these parameters will result in an increase in exposure. Key parameter values used in models are shown in Table 2-9. Material specific solid phase diffusion rates were calculated for each item as described in Section 2.4.1. For contact area, professional judgment was used to determine reasonable contact areas for each product or article assuming typical use. For items which were considered to have a high level of uncertainty or variability, different surface areas were assumed in low, medium, and high scenarios. Solid phase diffusion coefficients were estimated as outlined in Section 2.4.1. The same value derived for emissions from bedding materials (5.79×10^{-10} m²/hour) was used to parameterize dermal exposure to clothing and bedding. A diffusion coefficient of 5.42×10^{-9} m²/hour was estimated for use in models for plastic, rubber and viscoelastic polymer items using the methods outlined in Section 2.3.1. Calculations, data sources, input parameters and results are also available in *Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025b](#)).

Duration of Article Contact

Estimated values for duration of article contact were based on use patterns reported in the *Exposure Factor Handbook* for bedding, plastic and rubber children's toys. When durations of use for the specific kind of article could not be referenced to the *Exposure Factor Handbook* or other sources, this value was based on professional judgment for clothing, footwear components, putties, and other viscoelastic toys. Given the high level of expected variability in use patterns, low, medium, and high estimates for exposure duration were used. Time spent sleeping and napping was used to determine dermal contact time to bedding. These values were taken from Table 16-26 in the *Exposure Factors Handbook* ([U.S. EPA, 2011b](#)). Because there was significant variability among age groups, dermal contact time was determined separately for children, youths, and adults. Data from the 1 to 4-year-old age group were used to populate scenarios for children, the 12 to 17-year-old age group for youths, and the 18 to 64-year-old data for adults. Medium and high exposure durations were determined as the mean and 95th percentile, respectively. Table 16-26 did not provide the time spent sleeping or napping at the 10th percentile that would correspond to the low exposure duration; only the 5th and 25th percentile was available. Therefore, EPA determined the low exposure duration to be the mean minus one standard deviation. The resulting values for dermal exposure duration (minutes/day) in low, medium, and high exposure scenarios were 608, 732, and 930 for children; 435, 564, and 780 for youths; and 374, 497, and 705 in adults.

For clothing and footwear components, all age groups were assumed to have the same potential for dermal contact. The exposure duration used in the high-intensity use scenario is 16 hours a day (960 minutes) based on CEM's default. Based on professional judgment, the exposure duration for the medium- and low- intensity use duration is 480 minutes and 240 minutes per day, respectively. These exposure durations are based on the expectation that people may go out for shorter events or activities and may or may not change their clothing and shoes between indoors and outdoors.

For plastic and rubber children's toys, data were taken from Table 16-26 in the *Exposure Factors Handbook* for playtime for children under 15 years of age ([U.S. EPA, 2011b](#)). Minimum, mean, and maximum values (24 minutes per day, 88 minutes per day, and 137 minutes per day) were used in low, medium, and high exposure scenarios, respectively. Based on professional judgment from review of the article's use description, contact time with putties and other viscoelastic toys was expected to be significantly lower than plastic and rubber toy items; contact durations of 15 minutes per day, 30 minutes per day, and 60 minutes per day were used in low, medium, and high exposure scenarios.

Frequency of Contact

For articles, assumptions about frequency of use were made based on professional judgment. For articles which could be expected to be used on a routine basis, such as plastic and rubber children's toys, bedding, clothing, and footwear, use was assumed to be once per day every day. For putties and viscoelastic toys, use frequency was modeled as once a week based on a combination of reviews on retailer websites and professional judgment.

Table 2-9. Key Parameters Used to Model Dermal Uptake from Solid Articles

Product	Exposure Level	Conc. (mg/cm ³) ^a	Contact Time for Infants and Children (mins/day)	Contact Time for Teens (mins/day)	Contact Time: Adults (mins/day)	Solid Phase Diffusion (m ² /hr) ^d	Contact Area ^e
Clothing	High	7.75E-01	960 ^c	960 ^c	960 ^c	5.79E-10	Entire body
	Medium	1.55E-01	480 ^c	480 ^c	480 ^c		Entire body
	Low	4.65E-04	240 ^c	240 ^c	240 ^c		Entire body
Bedding	High	7.75E-01	930 ^b	780 ^b	705 ^b	5.79E-10	Entire body
	Medium	1.55E-01	732 ^b	564 ^b	497 ^b		50% of entire body surface area
	Low	4.65E-04	608 ^b	453 ^b	374 ^b		25% of face, hands, and arms
Plastic and rubber toys	High	1.34E+00	137 ^b	Not assessed	Not assessed	5.42E-09	Inside of two hands (palms, fingers)
	Medium	4.02E-01	88 ^b				Inside of one hand (palms, fingers)
	Low	1.34E-01	24 ^b				10% of Hands (some fingers)
Rubber footwear components	High	6.70E-01	960 ^c	960 ^c	960 ^c	5.42E-09	Inside of two hands (palms, fingers)
	Medium	4.02E-01	480 ^c	480 ^c	480 ^c		Inside of two hands (palms, fingers)
	Low	1.34E-01	240 ^c	240 ^c	240 ^c		Inside of two hands (palms, fingers)
	High	1.34E01	60 ^c	60 ^c	60 ^c	1.93E-04	Inside of one hand (palms, fingers))

Product	Exposure Level	Conc. (mg/cm ³) ^a	Contact Time for Infants and Children (mins/day)	Contact Time for Teens (mins/day)	Contact Time: Adults (mins/day)	Solid Phase Diffusion (m ² /hr) ^d	Contact Area ^e
Putties and other viscoelastic polymer toys	Medium	6.70E-01	30 ^c	30 ^c	30 ^c		10% of hands (some fingers)
	Low	1.34E-01	15 ^c	15 ^c	15 ^c		10% of hands (some fingers)

^a See Section 2.1.1 for sources of D4 concentration in specific articles.
^b Input was from Table 16-26 in the *Exposure Factor Handbook* (U.S. EPA, 2011b).
^c For clothing at the high-intensity use scenario, input is based on CEM Version 3.2's default of 16 hours. Contact time for medium- and low-intensity use scenarios are on professional judgment. All other inputs are also based on professional judgment following review of article use description.
^d Input is calculated as shown in the *Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4)* (U.S. EPA, 2025b).
^e Input is based on defaults from CEM Version 3.2 (U.S. EPA, 2023).

2.6 Mouthing Modeling Approach

The amount of D4 that is transferred from a solid article to saliva during mouthing is generally controlled by the ability of the chemical to partition from the solid phase to air, migrate through a solid matrix to the article surface, and then partition to saliva. This process is described by the chemical migration rate and is expressed in units of mass/cm²-hour. As no existing data quantifying the chemical migration rate of D4 was identified, a theoretical framework based on physical and chemical properties of D4 and the solid matrix material was employed to estimate this parameter. The selected model was developed based on a regression model and validated against chemical migration rates for a wide range of chemical classes in several materials. This model estimates chemical-material specific chemical migration rates based on physical and chemical properties of D4 and parameters which can be estimated based on the solid matrix material (Aurisano et al., 2022). The regression-based model takes the form of Equation 2-3.

Equation 2-3. Regression Model for Chemical Migration Rate from Aurisano (2022)

$$\log_{10}R_{mgr} = 3.23 + 0.73\log_{10}D_p + 0.92\log_{10}C_0 - 0.0610\log_{10}K_{OW}$$

Where:

R_{mgr}	=	Rate of chemical migration (µg/10 cm ² /mins)
D_p	=	Solid phase diffusion coefficient (cm ² /s)
C_0	=	Initial concentration of D4 in the solid matrix (µg/cm ²)
K_{OW}	=	Octanal/water partitioning coefficient

The solid phase diffusion coefficient was calculated using the model outlined in Section 2.4.1.

2.6.1 Modeling Inputs and Parameterization for Estimating Mouthing Exposure to D4 Emitted from Solid Articles

Key parameters that contribute to ingestion by mouthing include chemical migration rate, mouthing surface area, and mouthing duration. Any increase in these parameters will result in increased D4 exposure. Chemical migration rates were calculated as described above. Derivation of all other key

parameters is described below and summarized in Table 2-11 at the end of this section.

Mouthing Surface Area

The parameter “mouthing surface area” refers to the specific area of an object that comes into direct contact with the mouth during a mouthing event. A standard value of 10 cm² for mouthing surface area (OECD, 2019) is commonly used in studies to estimate mouthing exposure in children. This standard value is based on empirical data reflecting typical mouthing behavior in young children, providing a reliable basis for estimating exposure levels and potential health risks associated with mouthing activities. The value of 10 cm² was thus chosen for use in all mouthing exposure models for children. Mouthing activities are expected to cease for people 6 years and older.

Mouthing Duration

Mouthing durations were obtained from Table 4-23 in the *Exposure Factors Handbook* (U.S. EPA, 2011b) which provides mean mouthing durations for children between 1 month and 5 years of age, broken down by age groups expected to be behaviorally similar. Mouthing durations are provided for toys, pacifiers, fingers, and other objects. For this assessment, mouthing durations for toys were used for soft fabric, as well as rubber and plastic children’s toys. Mouthing durations for pacifiers were used for rubber and plastic items meant to be mouthed. The data provided in the *Exposure Factors Handbook* was broken down into more age groups than available in CEM. For example, it provides different mouthing durations for infants 12–15 months, 15–18 months, 18–21 months, and 21–24 months of age; CEM, in contrast, has only one age group for infants under 1 year of age.

To determine the mouthing duration in CEM, all relevant data from Table 4-23 in the *Exposure Factors Handbook* (U.S. EPA, 2011b) were considered together. The minimum value by item type within each age group was used in the low exposure scenario, the mean value (average across the age groups) in the medium exposure scenario, and maximum value in the high exposure scenario, as shown in Table 2-10. The minimum value by item type within each age group was used in the low exposure scenario, the mean value (average across the age groups) in the medium exposure scenario, and maximum value in the high exposure scenario, as shown in Table 2-10.

Table 2-10. Mouthing Durations for Children for Toys and Other Objects

Item Mouthed	Estimated Mean Daily Mouthing Duration Values from Table 4-23 in the <i>Exposure Factors Handbook</i> (mins/day)				Mouthing Durations for CEM Age Groups (mins/day)		
	Reported Age Group				CEM Age Group: Infants (<1 year)		
	1–3 Months	3–6 Months	6–9 Months	9–12 Months	High Exposure Scenario	Medium Exposure Scenario	Low Exposure Scenario
Toy	1.0	28.3	39.2	23.07	39.2	22.9	1.0
Other object	5.2	12.5	24.5	16.42	24.5	14.7	5.2
Item Mouthed	Reported Age Group				CEM Age Group: Toddler (1–2 years)		
	12–15 Months	15–18 Months	18–21 Months	21–24 Months	High Exposure Scenario	Medium Exposure Scenario	Low Exposure Scenario
Toy	15.3	16.6	11.1	15.8	16.6	14.7	11.1
Other object	12.0	23.0	19.8	12.9	23.0	16.9	12.0

Item Mouthed	Reported Age Group				CEM Age Group: Preschooler (3–5 years)		
	2 Years	3 Years	4 Years	5 Years	High Exposure Scenario	Medium Exposure Scenario	Low Exposure Scenario
Toy	12.4	11.6	3.2	1.9	12.4	7.3	1.9
Other object	21.8	15.3	10.7	10.0	21.8	14.4	10.0

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1216 **Table 2-11. Key Inputs for Mouthing Models**

Article	Exposure Level	Mouthing Area (cm ²) ^a	Chemical Migration Rate(µg/10 cm ² /min) ^b	Mouthing Duration (<1 year) (min/day) ^c	Mouthing Duration (1–2 years) (min/day) ^c	Mouthing Duration Preschooler (3–5 years) (min/day) ^c
Soft toys	High	10	1.93E–01	39.17	16.57	12.38
	Medium	10	4.40E–02	22.89	14.69	7.27
	Low	10	2.10E–04	1.00	11.12	1.88
Plastic and rubber items meant to be mouthed	High	10	1.43E–01	47.22	69.37	48.70
	Medium	10	4.13E–02	33.45	45.05	24.65
	Low	10	3.04E–04	14.60	25.20	0.33
Plastic and rubber toys	High	10	1.19	39.17	16.57	12.38
	Medium	10	3.92E–01	22.89	14.69	7.27
	Low	10	1.43E–01	1.00	11.12	1.88
^a Standard value of 10 cm ² for mouthing surface area (OECD, 2019). ^b Calculated using Equation 2-3. ^c Mouthing duration used in CEM from Table 4-23 in the <i>Exposure Factors Handbook</i> (U.S. EPA, 2011b).						

1217

3 CONSUMER EXPOSURE MODELING RESULTS

This section summarizes the dose estimates from inhalation, ingestion, and dermal exposure to D4 in consumer products and articles. For ingestion and dermal exposures, risk estimates are based on potential dose. For inhalation exposure, risk estimates are based on the exposure concentration of the chemical in air. As such, inhalation doses are provided below to contextualize relative potential for exposure between routes, and exposure concentrations are also provided. Exposure via the inhalation route is assumed to occur from inhalation of D4 gas-phase emissions from products and articles. Exposure via the dermal route is assumed to occur from direct contact with products and articles. Exposure via ingestion is assumed to occur from article mouthing. The exposure estimates presented in this section represent potential doses rather than actual absorbed doses, meaning the total dose of chemical ingested, dermally absorbed, or inhaled without regard for absorption efficiency. This approach was taken because the benchmark dose values used to characterize risks were derived from a PBPK model that already accounts for absorption and internal distribution *Draft Human Health Hazard Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025f](#)). Absorption of D4 is expected to vary by route of exposure, potentially resulting in different patterns for internal dose than those presented here.

3.1 Non-Cancer Acute Dose Results, Conclusions, and Data Patterns

The *Draft Consumer Risk Calculator for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025c](#)) summarizes the low, medium, and high ADR results for all lifestages from CEM and IECCU modeling for inhalation exposures. It also includes dermal and ingestion exposure estimates that were separately calculated outside of CEM and IECCU. Products and articles marked with a dash (-) do not have dose results because the product or article was not targeted for that lifestage or exposure route. Dose results applicable to bystanders are highlighted. Bystanders are people that are not in direct use or application of a product but can be exposed to D4 by proximity to the use of the product via inhalation of gas-phase emissions. In instances where a lifestage could reasonably be either a product user or bystander, the user scenario inputs were selected because proximity to the product during use would result in larger exposure doses. The *Draft Consumer Risk Calculator for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025c](#)) summarizes acute dose rate results, show which products or articles did not have a quantitative result, and which results are used for bystanders. Data patterns are illustrated in figures below and include summary descriptions of the patterns by exposure route and population or lifestage. Modeled values are presented for each of the lifestages evaluated in the *Draft Consumer Risk Calculator for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025c](#)), but the summary figures averaged the values for certain subgroups due to their similarities.

Figure 3-1 through Figure 3-4 show acute dose rate data for all products and articles modeled in all lifestages assessed. The figures show ADR estimated from exposure via inhalation, ingestion by mouthing, and dermal contact. For all lifestages, indoor use of paints and lacquers and laundry detergent led to the highest ADRs for inhalation. This is particularly noteworthy as only teen and adult groups were modeled as product users and younger lifestages were modeled as bystanders. However, the results of this analysis indicate that bystander inhalation exposure may still be large, especially for spray applied products used in the home. Dermal exposure was the most primary driver of exposure from solid articles.

The spread of values estimated for each product or article reflects the aggregate effects of variability and uncertainty in key modeling parameters for each item. Acute dose rate for some products and articles covers a larger range than others primarily due to a wider distribution of D4 weight fraction values and behavioral factors such as duration of use or contact time and mass of product used as described in

Section 2. Key differences in exposures among lifestages include designation as product user or bystander, behavioral differences such as mouthing durations, and dermal contact expected from touching specific articles which may not be appropriate for some lifestages.

Across all routes, inhalation and dermal uptake of D4 from the use of paints and lacquers resulted in the highest potential doses. Dermal uptake was not evaluated for children 10 years and younger because they are not considered users with direct contact to the product. Inhalation of D4 emitted from these products was also significant for children 10 years and younger even though they were modeled as bystanders during both a large (*i.e.*, outdoor) and small (*i.e.*, indoor in a garage) project. A key driver of inhalation in this scenario is weight fractions of D4 in these products. Paint and lacquers had the highest weight fractions among all products evaluated and known to contain D4, with a maximum value of 25 percent and 20 percent for products suitable for small and large projects, respectively. The next highest weight fraction was for auto care products modeled for use in a garage. Inhalation doses for outdoor use of paint and lacquers and indoor use of auto care products were approximately within the same order of magnitude even though the maximum weight fraction for auto care products is 10 percent. This indicates that room of use and thus level of ventilation is another important parameter controlling inhalation exposure, which is expected because there is less mixing with outdoor air in an indoor environment. Another product resulting in high acute inhalation exposure was liquid and solid-based detergents. Exposure was modeled to occur during the wash cycle when D4 is added to the water and then evaporates. For the detergent scenario, weight fraction, ventilation levels, and use time were drivers of inhalation exposure. Increasing the value for each of these parameters will also increase D4 emissions and thus inhalation exposure.

Dermal contact to bedding and clothing resulted in the second highest potential doses for acute scenarios and for all lifestages. Many fabric and textile items were reported to contain D4 at relatively low concentrations. However, high dermal doses for bedding were estimated because of the large surface area and long duration for article contact.

Ingestion exposure was evaluated for only children five years and younger via mouthing of soft toys, plastic and rubber items meant to be mouthed, and plastic and rubber toys. The key parameters contributing to ingestion exposure for children is the mouthing duration and weight fraction of D4. Variability between age groups is driven largely by mouthing duration; doses are lower for older children compared to infants and toddlers across all exposure scenarios because mouthing duration decreases with age. The variability between low, medium, and high estimates for individual items and variability between item types is driven primarily by chemical weight fractions, which vary by 2 to 4 orders of magnitude between low and high scenarios, and to a lesser extent by mouthing durations.

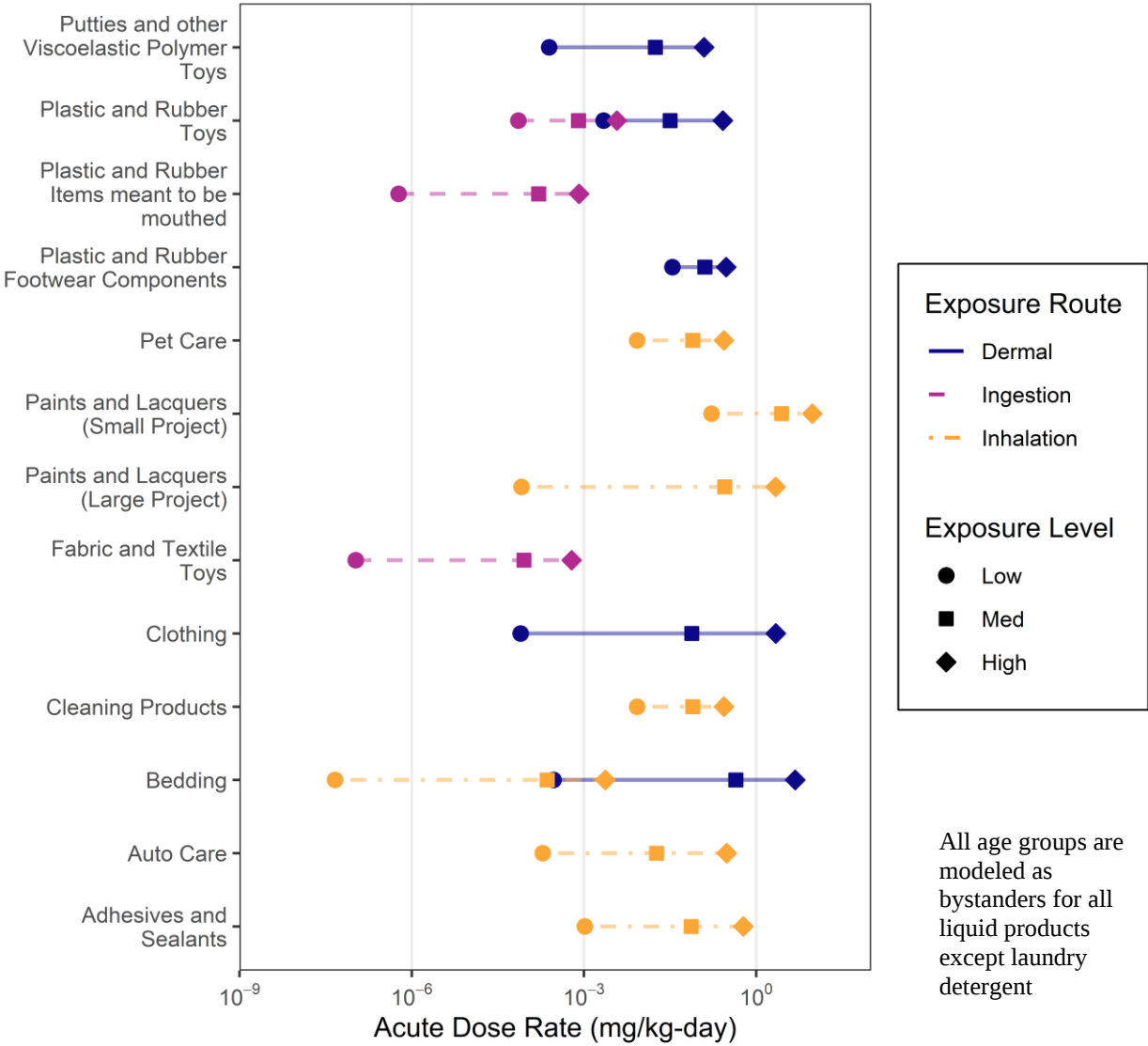


Figure 3-1. Acute Dose Rate for Ingestion, Inhalation, and Dermal Exposure Routes for Infants (<1 Year Old) and Toddlers (1–2 Years Old)

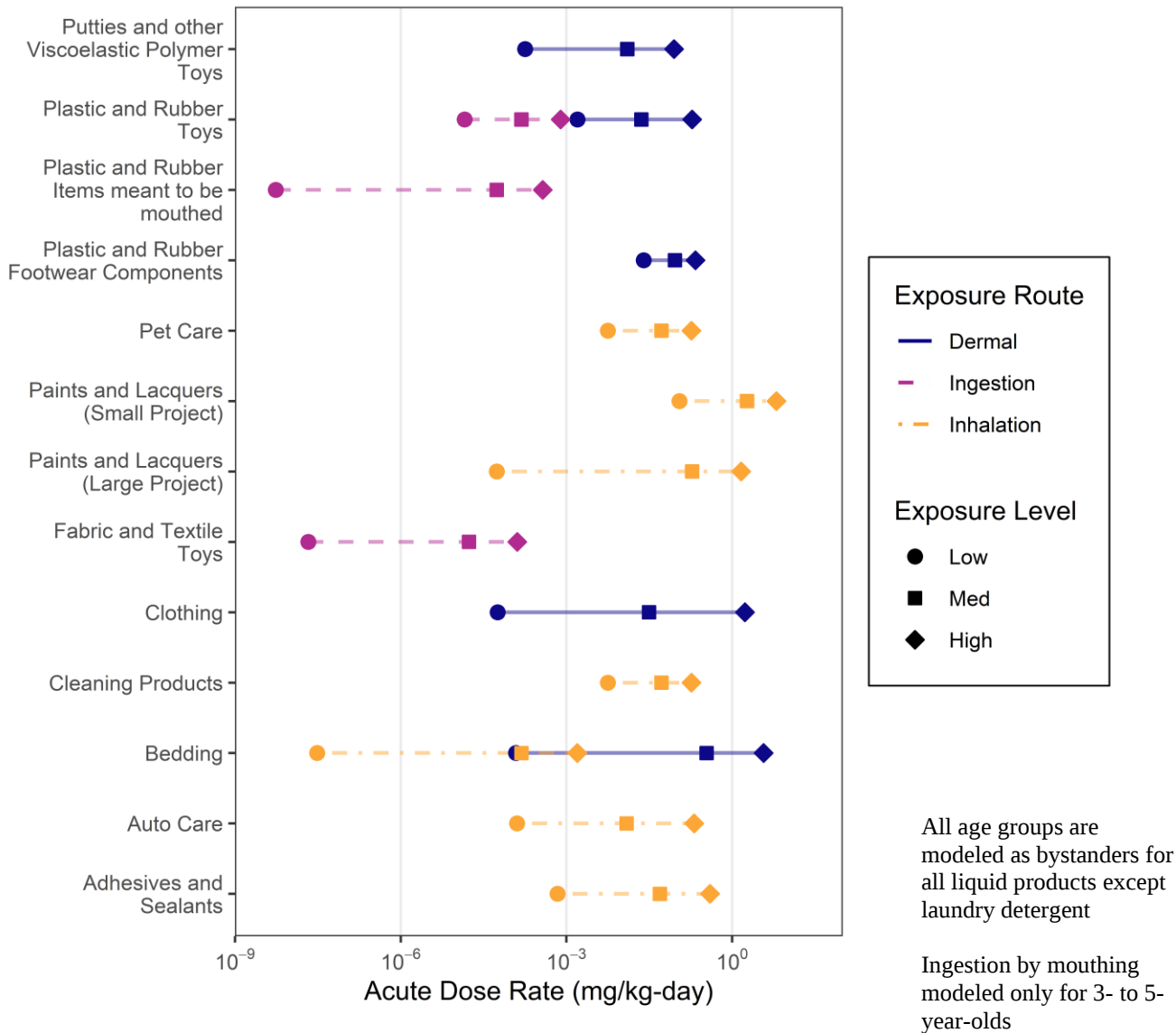


Figure 3-2. Acute Dose Rate for Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers (3–5 Years Old) and Middle Childhood (6–10 Years Old)

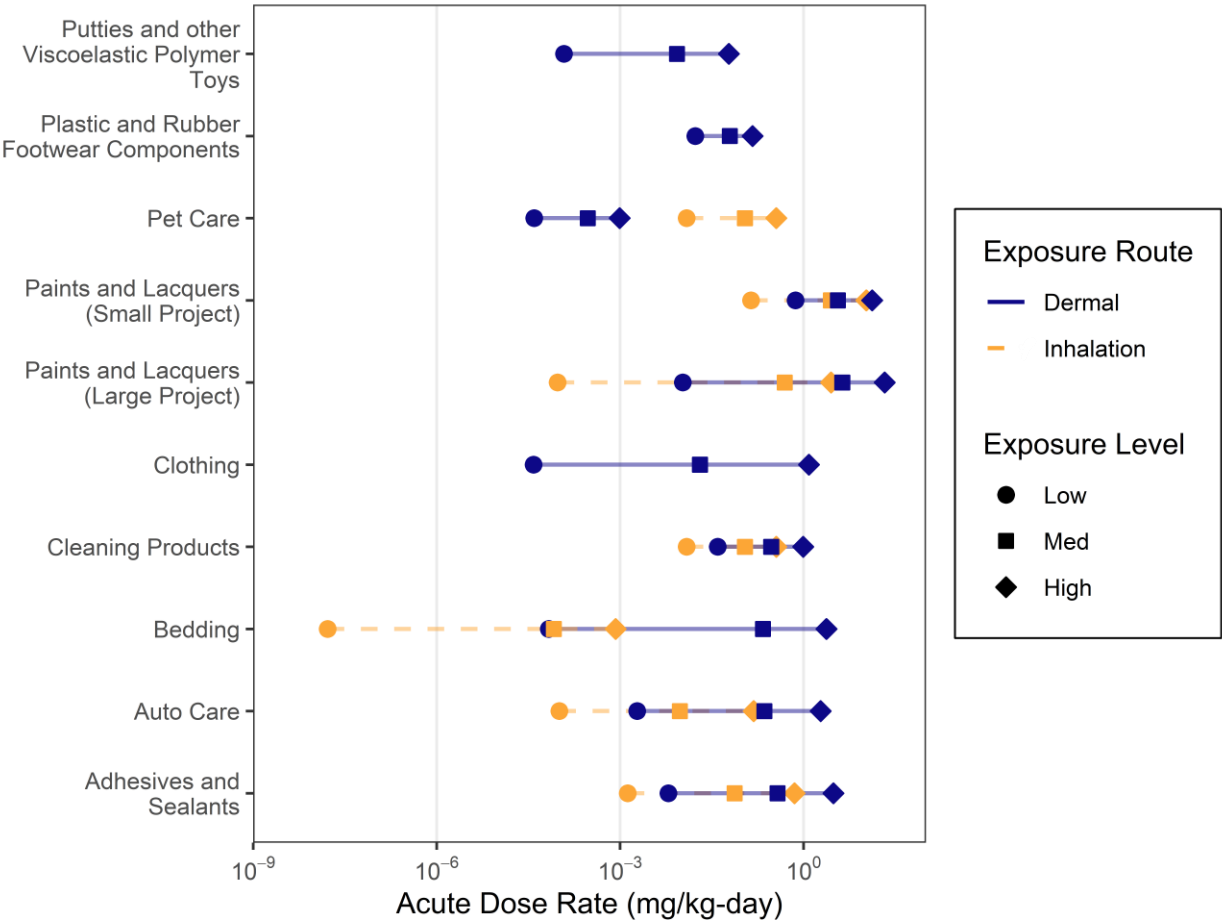


Figure 3-3 Acute Dose Rate for Inhalation and Dermal Exposure Routes for Young Teens (11–15 Years Old) and Teenagers and Young Adults (16–20 Years Old)

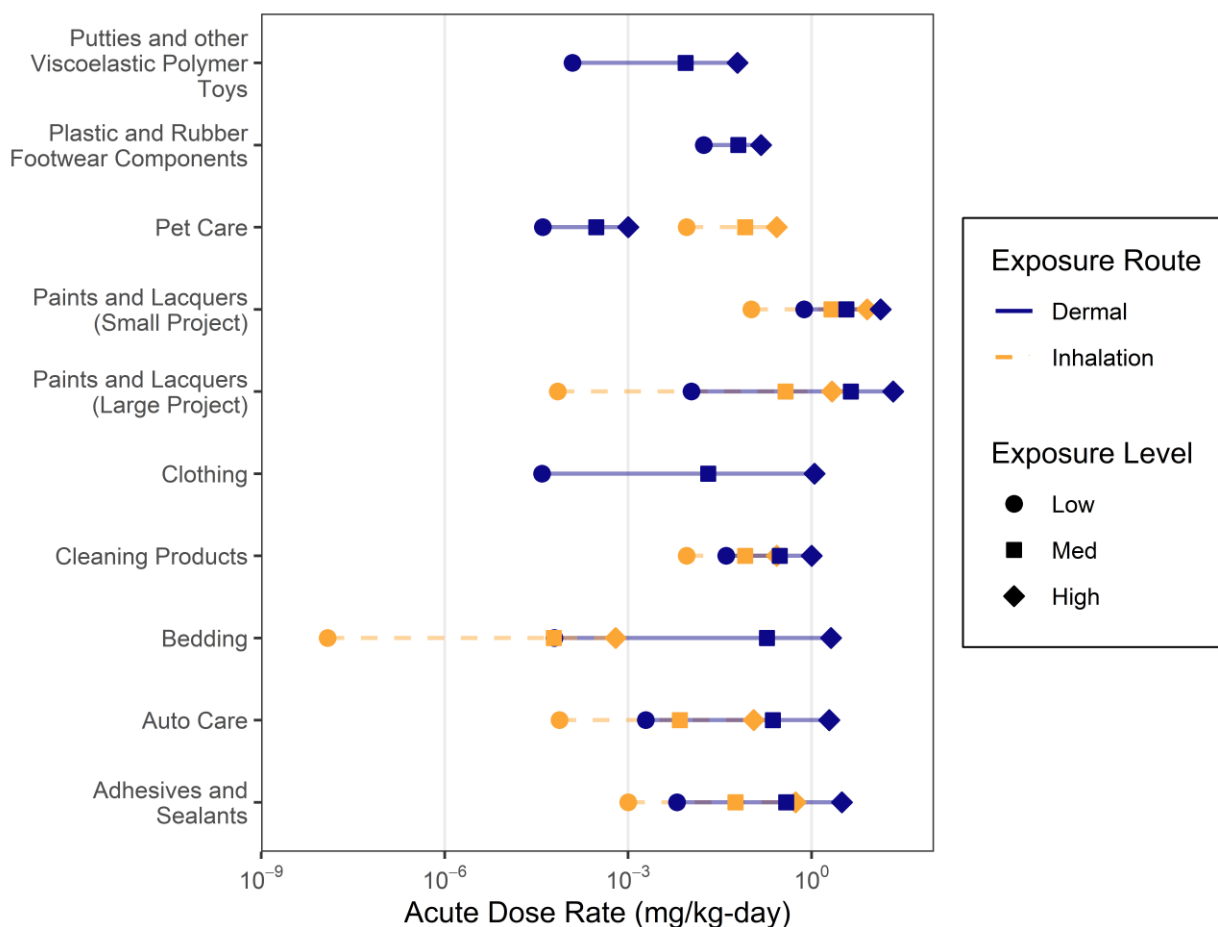


Figure 3-4 Acute Dose Rate for Inhalation and Dermal Exposure Routes for Adults (20+ Years Old)

The acute exposure concentrations in air resulting from D4 emissions from each product or article modeled for inhalation exposure are provided in Table 3-1. For each product or article, reported concentrations were averaged over the highest 24-hour period of modeling. Because movement patterns through the home are the same for all age groups, the exposure concentration for solid articles is the same for all individuals in the home. For products, variability in exposure concentration is due to status as a product user or bystander. As expected, exposure concentrations of D4 in air are higher for product users than bystanders.

Table 3-1. Acute Exposure Concentrations of D4 in Air Emitted from Consumer Products and Articles (mg/m³)

Product or Article	Exposure Level	Exposure Concentration (mg/m ³)		
		Product Bystanders	Product Users	All Age Groups
Adhesives and sealants	High	8.7E-01	2.6	
	Medium	1.1E-01	2.8E-01	
	Low	1.5E-03	5.2E-03	
Auto Care products	High	4.5E-01	6.1E-01	
	Medium	2.7E-02	3.8E-02	
	Low	2.8E-04	4.1E-04	

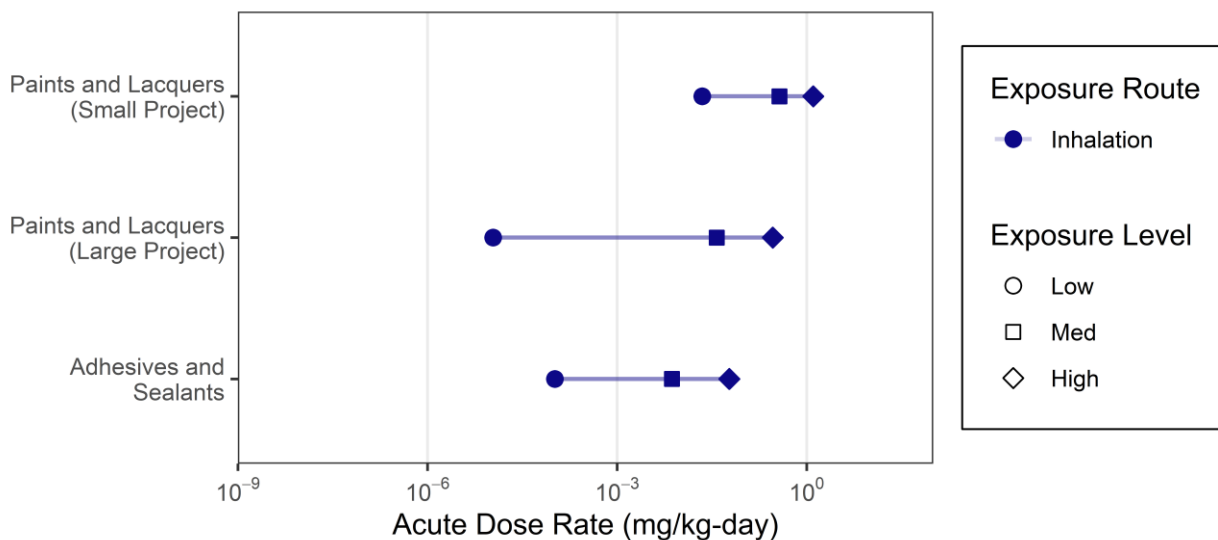
Product or Article	Exposure Level	Exposure Concentration (mg/m ³)		
		Product Bystanders	Product Users	All Age Groups
Bedding	High			1.8
	Medium			1.8E-01
	Low			3.5E-05
Cleaning products	High	4.0E-01	1.4	
	Medium	1.1E-01	4.4E-01	
	Low	1.2E-02	4.9E-02	
Laundry detergent (solid/liquid)	High			2.1
	Medium			8.4E-01
	Low			1.4E-01
Paint and lacquer (large projects)	High	3.2	1.0E01	
	Medium	4.1E-01	1.9	
	Low	5.6E-05	2.1E-04	
Paint and lacquer (small projects)	High	1.4E01	4.0E01	
	Medium	4.0	1.1E01	
	Low	1.2E-01	3.0E-01	
Animal grooming products	High	4.0E-01	1.4	
	Medium	1.1E-01	4.4E-01	
	Low	1.2E-02	4.9E-02	

3.2 Intermediate Average Daily Dose Results, Conclusions, and Data Pattern)

Table 3-2 summarizes all the low-, medium-, and high-intensity use intermediate dose results from modeling for all exposure routes and all lifestyles. For intermediate exposure modeling, product selection was based on expected use patterns. Products that were used routinely were excluded from intermediate exposure estimates, as their exposures are adequately represented by chronic exposure values. However, for products commonly used in home DIY projects, product reviews on retailer websites indicated that consumers may use some products repeatedly over a relatively short period to complete a project. These use patterns would result in higher exposure than would be captured if the product use is assumed to occur over a one-year period as in chronic exposure models. Intermediate exposure estimates were calculated based on 30 days of use.

Only adhesives and sealants, as well as lacquers and paints used in both small indoor and large outdoor projects, were modeled for intermediate exposure scenarios. Based on consumer product reviews, manufacturer use descriptions, and professional judgment, adhesives and sealants were modeled for use frequency of 3 times in one month, and lacquers and paints used in both small indoor and large outdoor projects were modeled for use frequency of four times a month. All other model inputs were as previously described. As in previous results, infants and children are not modeled as product users but may be exposed via inhalation as bystanders during use. Overall, patterns in potential intermediate exposure were similar to acute patterns previously described.

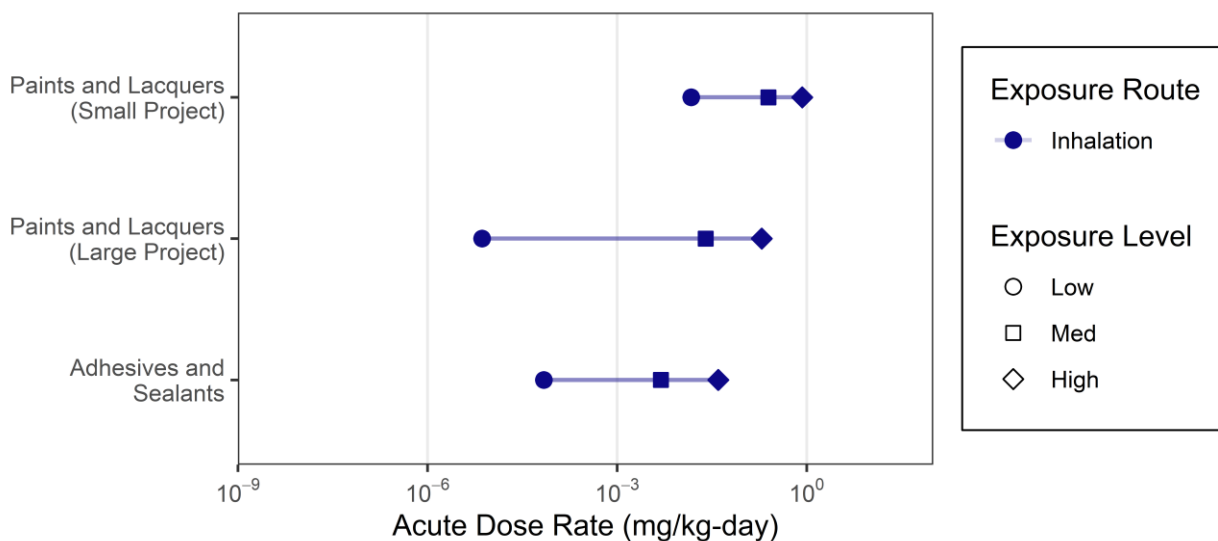
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1352 **Figure 3-5. Intermediate Dose Rate for Inhalation Exposure for Infants (<1 Year Old) and**
1353 **Toddlers (1-2 Years Old) as Bystanders**

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1356 **Figure 3-6. Intermediate Dose Rate for Inhalation Exposure Routes for Preschoolers (3-5 Years**
1357 **Old) and Middle Childhood (6-10 Years Old) as Bystanders**

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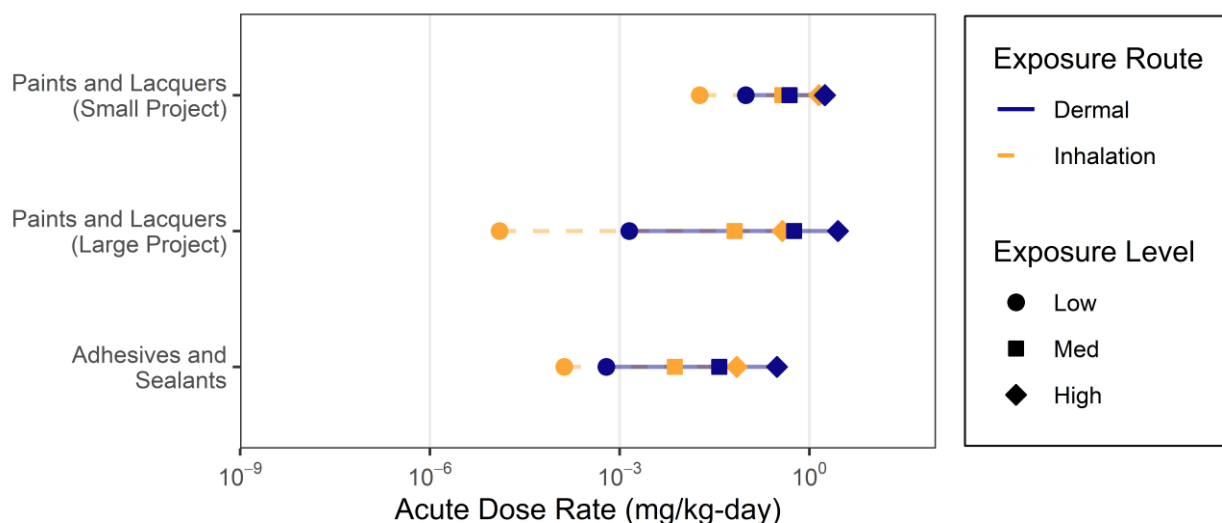


Figure 3-7. Intermediate Dose Rate for Inhalation and Dermal Exposure Routes for Young Teens (11–15 Years Old) and Teenagers and Young Adults (16–20 Years Old)

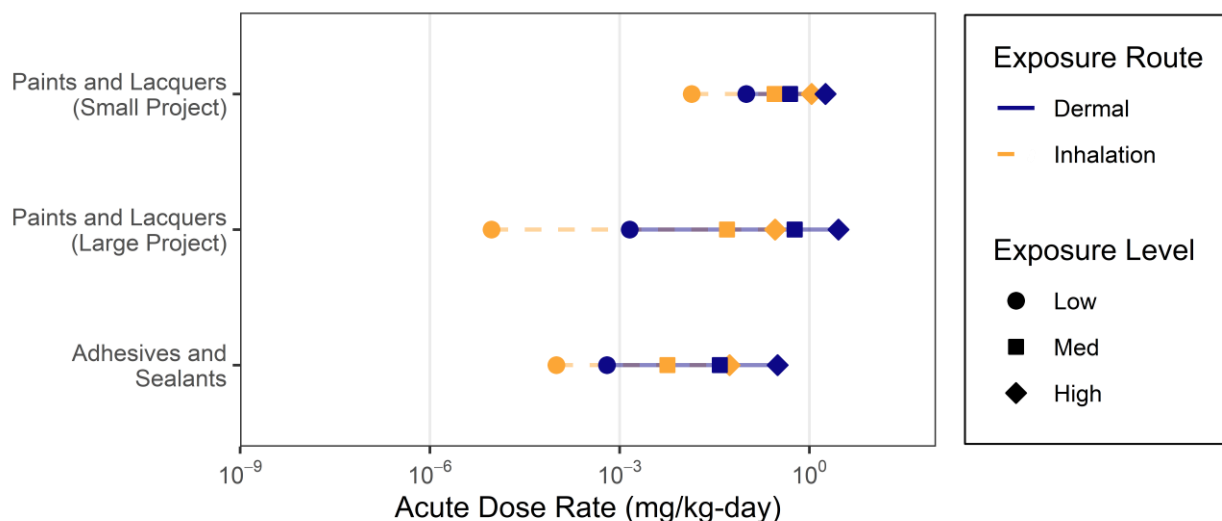


Figure 3-8. Intermediate Dose Rate for Inhalation and Dermal Exposure Routes for Adults (20+ Years Old)

Table 3-2. Intermediate Exposure Concentrations of D4 in Air Emitted from Consumer Products and Articles (mg/m³)

Product or Article	Exposure Level	Exposure Concentration (mg/m ³)	
		Product Users	Product Bystanders
Adhesives and sealants	High	8.7E-02	2.6E-01
	Medium	1.1E-02	2.8E-02
	Low	1.5E-04	5.2E-04
Paint and lacquer (large projects)	High	4.2E-01	1.4
	Medium	5.4E-02	2.6E-01
	Low	7.5E-06	2.8E-05

Product or Article	Exposure Level	Exposure Concentration (mg/m ³)	
		Product Users	Product Bystanders
Paint and lacquer (small projects)	High	1.9	5.3
	Medium	5.5E-01	1.5
	Low	1.6E-02	4.0E-02

3.3 Non-Cancer Chronic Dose Results, Conclusions, and Data Patterns

The *Draft Consumer Risk Calculator for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025c](#)) summarizes the low-, medium-, and high-intensity use chronic daily dose results for all exposure routes and all lifestages. Some products and articles did not have dose results because the product or article was not targeted for that lifestage or exposure route. Bystanders are people that are not in direct use or application of the product but can be exposed to D4 by proximity to the use of the product via inhalation of gas-phase emissions. In instances where a lifestage could reasonably be either a product user or bystander, the user scenario inputs were selected because proximity to the product during use would result in larger exposure doses. The *Draft Consumer Risk Calculator for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025c](#)) summarizes chronic daily dose results, show which products or articles did not have a quantitative result, and which results are used for bystanders. This section summarizes data patterns with figures and describes the patterns by exposure route and population or lifestage. Modeled values are presented for each of the seven lifestages evaluated in the draft risk calculator, but the summary figures averaged the values for certain subgroups due to their similarities.

Figure 3-9 through Figure 3-12 show chronic average daily dose (CADD) estimated from exposure via inhalation, ingestion by mouthing, and dermal contact for all products and articles and lifestages assessed. The CADD figures resulted in similar overall data patterns as the acute doses with some differences driven by the chronic exposure durations. For example, inhalation remained the most important exposure route for liquid products across all age groups, but overall exposures were significantly lower than the acute scenarios because none of the identified products were expected to be used on a daily basis. An exception is laundry detergent that is used routinely. Chronic inhalation exposure to D4 from detergent is thus similar to if not greater than acute for some scenarios. For solid articles, the values for CADD were often not significantly lower than the acute values because daily contact with these items was expected. Dermal contact with solid articles was a significant driver of chronic exposure among all age groups, particularly for items with large areas of dermal contact (*e.g.*, clothing, bedding). The CADD figures for ingestion via mouthing reflect similar overall data patterns as the acute doses, where weight fraction and mouthing durations are key drivers of exposure.

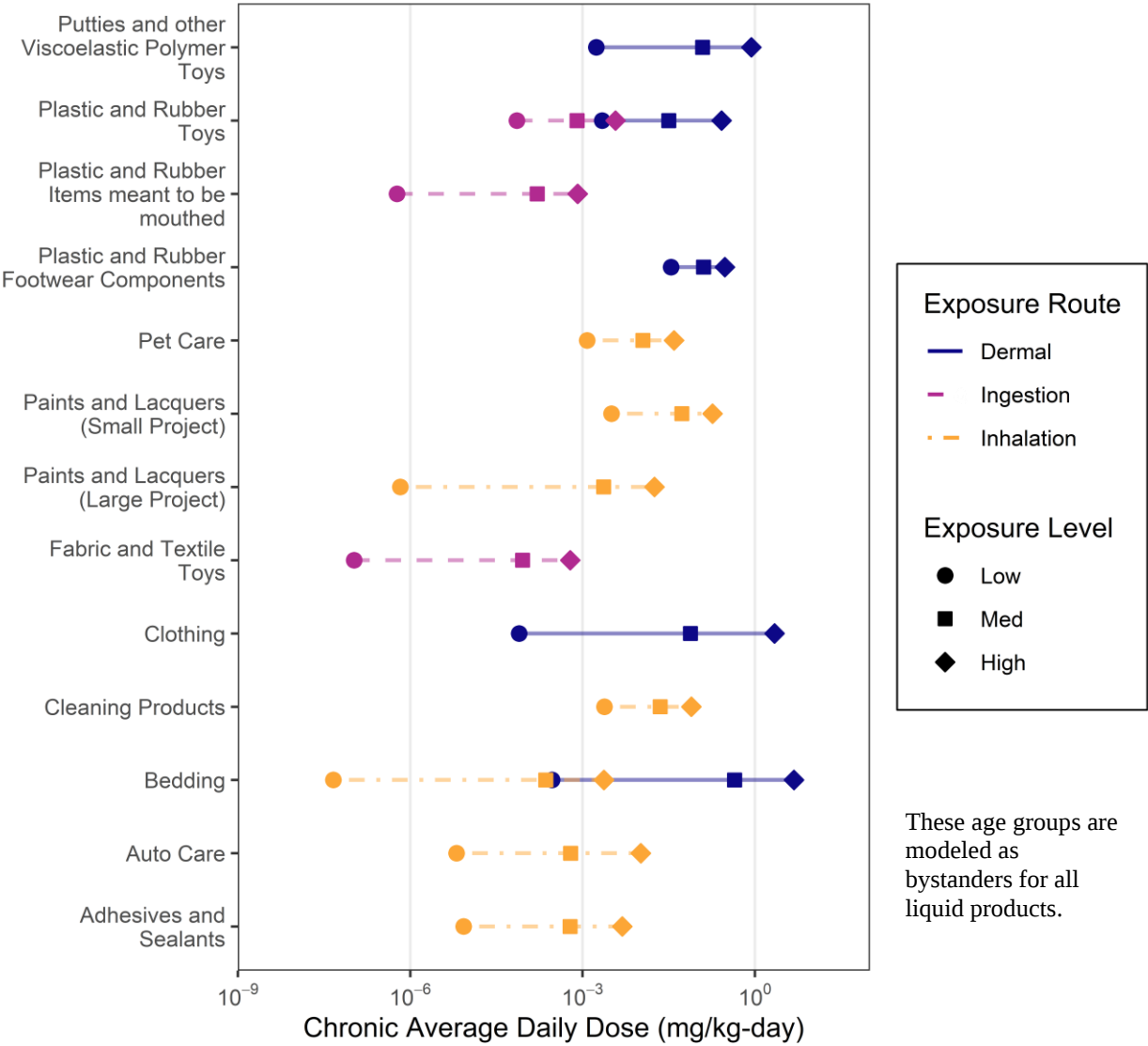


Figure 3-9. Chronic Average Daily Dose for Ingestion, Inhalation, and Dermal Exposure Routes for Infants (<1 Year Old) and Toddlers (1-2 Years Old)

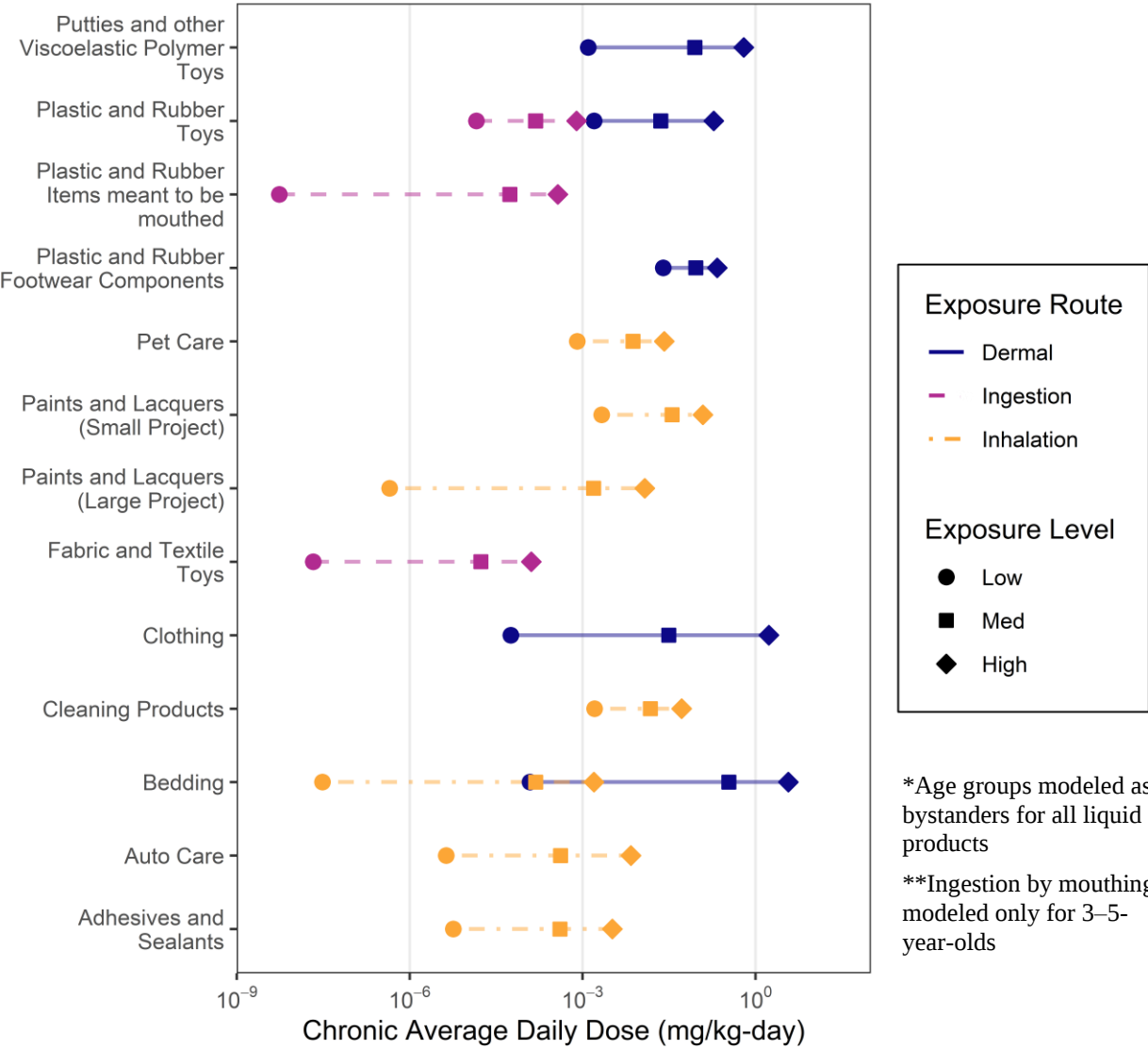


Figure 3-10 Chronic Average Daily Dose for Ingestion, Inhalation, and Dermal Exposure Routes for Preschoolers (3–5 Years Old) and Middle Childhood (6–10 Years Old)

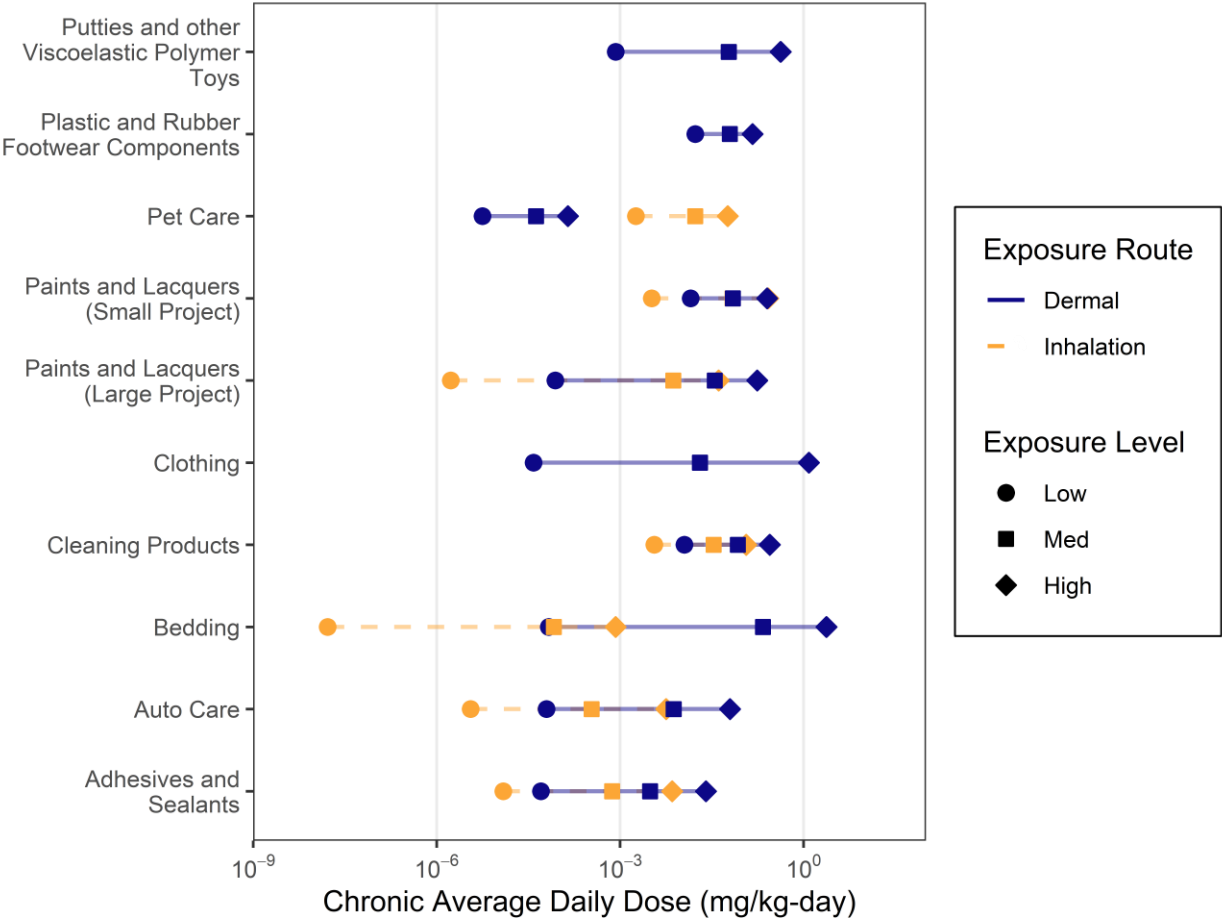


Figure 3-11 Chronic Average Daily Dose for Inhalation and Dermal Exposure Routes for Young Teens (11–15 Years Old) and Teenagers and Young Adults (16–20 Years Old)

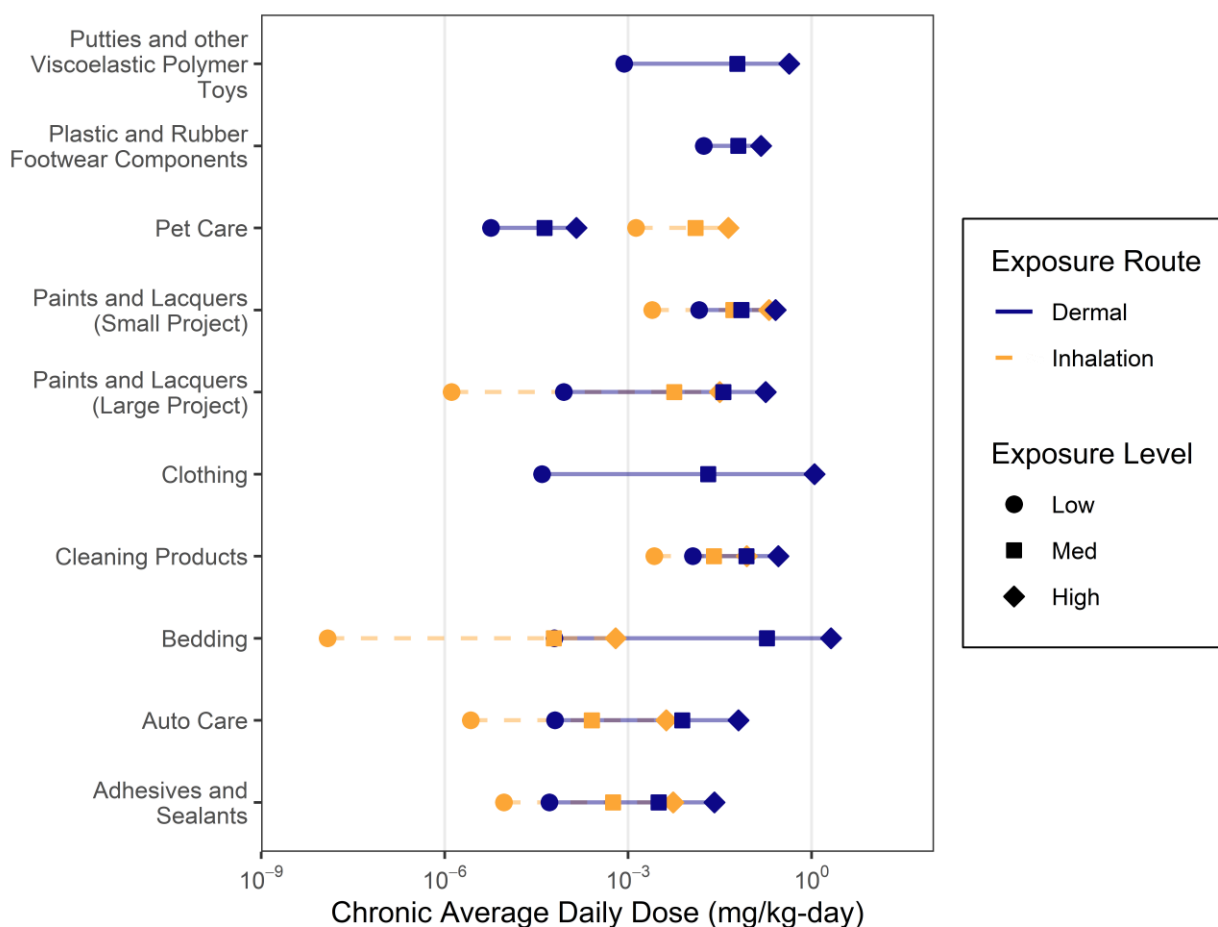


Figure 3-12 Chronic Average Daily Dose for Inhalation and Dermal Exposure Routes for Adults (20+ Years Old)

The chronic exposure concentrations in air resulting from D4 emissions from each product or article modeled for inhalation exposure are provided below in Table 3-3. For each product or article, reported concentrations were averaged over the entire period of modeling. Because movement patterns through the home are the same for all age groups, the exposure concentration for solid articles is the same for all individuals in the home. For products, variability in exposure concentration is due to status as a product user or bystander. As expected, exposure concentrations of D4 in air are higher for product users than bystanders, and exposure concentrations are lower in chronic scenarios than acute due to infrequent long-term use of products. For bedding, exposure concentrations of D4 were also lower in chronic scenarios than acute because emissions from solid articles decline with time.

Table 3-3. Chronic Exposure Concentrations of D4 in Air Emitted from Consumer Products and Articles (mg/m³)

Product or Article	Exposure Level	Exposure Concentration (mg/m ³)		
		Product Users	Product Bystanders	All Age Groups
Adhesives and sealants	High	7.1E-03	2.1E-02	
	Medium	8.8E-04	2.3E-03	
	Low	1.2E-05	4.3E-05	
Auto care products	High	1.5E-02	2.0E-02	
	Medium	8.8E-04	1.3E-03	

PUBLIC RELEASE DRAFT
September 2025

Product or Article	Exposure Level	Exposure Concentration (mg/m ³)		
		Product Users	Product Bystanders	All Age Groups
	Low	9.1E-06	1.4E-05	
Bedding	High			1.8
	Medium			1.8E-01
	Low			3.5E-05
Cleaning products	High	1.1E-01	4.0E-01	
	Medium	3.3E-02	1.2E-01	
	Low	3.5E-03	1.4E-02	
Laundry detergent (solid/liquid)	High			2.1
	Medium			6.9E-01
	Low			7.0E-02
Paint and lacquer (large projects)	High	2.6E-02	8.5E-02	
	Medium	3.3E-03	1.6E-02	
	Low	4.6E-07	1.7E-06	
Paint and lacquer (small projects)	High	2.7E-01	7.6E-01	
	Medium	7.9E-02	2.1E-01	
	Low	2.2E-03	5.8E-03	
Animal grooming products	High	5.7E-02	2.0E-01	
	Medium	1.6E-02	6.2E-02	
	Low	1.7E-03	7.0E-03	

1427
1428

4 INDOOR AIR AND DUST MONITORING STUDIES

To characterize the presence of D4 in indoor environments, a systematic review was conducted to compile data on measured concentrations in various indoor settings, sources contributing to indoor exposures, and its fate and transport behavior. D4 is a volatile organic compound with relatively high vapor pressure and low log K_{OA} . It is expected to transition readily from liquid and solid consumer goods to the air and partitioning to indoor surfaces and dust is expected to be low, resulting in fast dissipation of D4 after emission. Five studies were identified during systematic review that reported measured concentrations of D4 in residential dust that are not near industrial facilities. Of these, one reported D4 concentrations in indoor dust from the U.S. ranging from 4.95 to 371 ng/g for homes, laboratories, and offices ([Tran et al., 2015](#)). Four other studies measured D4 concentrations from 11 other countries that ranged from less than 3.0 to 1,290 ng/g, while the mean concentration across all studies and countries was less than 90 ng/g ([Liu et al., 2017](#); [Tran et al., 2015](#); [Xu et al., 2012](#); [Lu et al., 2010](#)). Lastly, one U.S. study measured D4 concentrations ranging from 17,900 to 169,000 ng/g in the particulate phase of indoor air samples ([Tran and Kannan, 2015](#)). It is important to note, however, that environmental factors including temperature and relative humidity on the day of sampling can affect partitioning of D4 in air. The suspended particulate in indoor air makes up only a fraction of indoor dust. Despite the apparent high concentration of D4 in the particulate phase of indoor air, it is still five times lower than the concentrations measured in the vapor phase. The findings from these studies are overall consistent with the expectation that D4 partitioning to dust will be negligible given its volatility.

D4 is commonly found in indoor air due to its use in cosmetics (*e.g.*, shampoo, lotion, deodorants). TSCA excludes cosmetics and drugs as defined in the Federal Food, Drug, and Cosmetic Act (FFDCA) (21 U.S.C. § 321). D4 is also found in cleaning agents, and various silicone-based materials. Thirteen studies were identified during systematic review that reported measured concentrations of D4 in indoor air (Figure 4-1). Of these, five U.S. studies were identified. Shields et al. ([1996](#)) will not be discussed because it sampled commercial buildings such as data centers and telecommunications that are not relevant to consumer exposure.

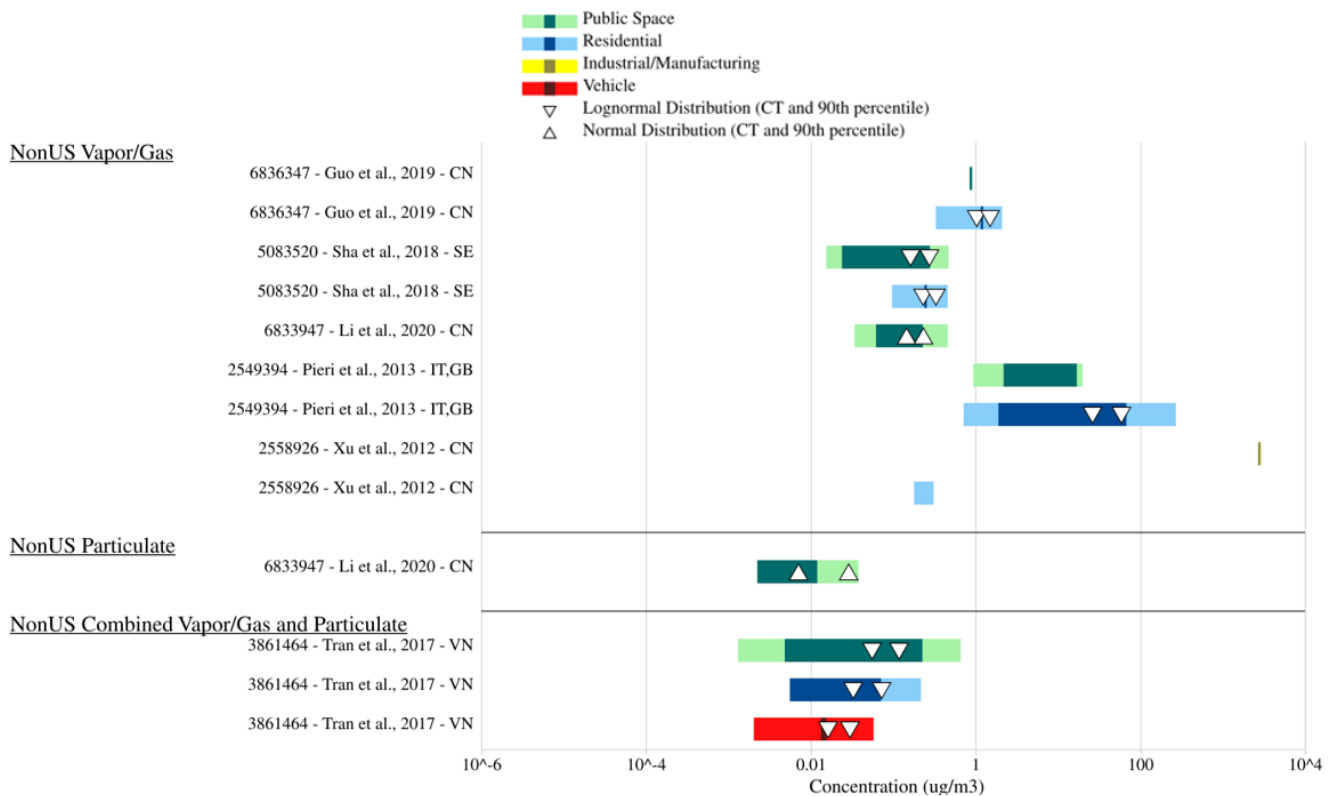


Figure 4-1. Concentrations of D4 in Indoor Air for Non-U.S. Studies

The lighter bar represents the range of the reported concentrations, and the darker bar represents the range of reported central tendencies. A study with only dark bars indicates that the only data reported was a measure of central tendency.

Tang et al. (2015) evaluated temporal patterns of D4 in air over the course of a day in a classroom at the University of California, Berkeley. Four class periods were scheduled in the classroom on the day of sampling. D4 concentrations in air for a single day ranged from background ($\sim 1 \mu\text{g}/\text{m}^3$) to about $27 \mu\text{g}/\text{m}^3$. Concentrations peaked at the beginning of the first class, declined to background concentrations by the end of class, and did not increase again over the day. The initial spike in D4 concentration is attributed to the use of personal care products at the beginning of the day followed by rapid dissipation. These results suggest that D4 from liquid products used indoors quickly evaporates, leading to minimal long-term increase in air concentration under well-ventilated conditions.

Moliner et al. (2022) also evaluated the temporal patterns of siloxane concentrations in residential air. Measurements were taken in two single family residences in California, as well as a test house at the University of Texas in Austin. Occupants of the residences in California went about normal activities, and sampling also included a multiday period when the homes were unoccupied. For both homes, samples were taken in the living zone at five-minute intervals. Mean air concentrations of D4 ranged from 0.92 to $2.99 \mu\text{g}/\text{m}^3$ when vacant and 1.34 to $5.75 \mu\text{g}/\text{m}^3$ when occupied. In one of the homes, periodic spikes in concentrations over a 15-day period were also observed, with maximums around $18 \mu\text{g}/\text{m}^3$. As D4 is not expected to undergo sorption and re-emission, this concentration profile suggests the occurrence of both continuous and event-specific emissions of D4. The authors attribute the continuous emissions to adhesives used in home construction and the event-specific emissions to the use of personal care products. There is however uncertainty regarding specific building materials or personal care products used in the homes, as well as if other items may contribute to exposure.

The test house had scripted activities (*e.g.*, cooking, cleaning) that allowed for D4 measurements to be taken during specific conditions, as well as when it was vacant for two days. Mean indoor air concentrations ranged from 0.35 to 1 $\mu\text{g}/\text{m}^3$. There was no increase in D4 concentration during cooking and cleaning events, and levels were significantly higher indoor than outdoor even when unoccupied.

Tran et al. (2015) reported D4 concentrations in airborne dust and filtered air sampled from homes ($n = 20$), offices ($n = 7$), laboratories, schools ($n = 6$), salons, and miscellaneous public places in Albany, New York. Measured concentrations in air ranged from 0.004 to 0.07 $\mu\text{g}/\text{m}^3$ in homes, 0.0001 to 0.07 $\mu\text{g}/\text{m}^3$ in offices, and 0.0063 to 0.016 $\mu\text{g}/\text{m}^3$ in schools. The authors suggest that the most likely source of D4 is personal care and household products. However, it is notable that reported D4 concentrations in both air and airborne dust were higher in schools than homes, despite a reasonable expectation that personal care products would be used in both greater quantity and frequency in homes as compared to schools. As previously discussed, D4 concentrations in air exhibit strong temporal variability over relatively short periods of time. As information on sampling times, school location or type, and product usage is lacking, it is not possible to attribute the relatively higher concentrations observed in schools to a particular source.

Yucuis et al. (2013) reported D4 concentrations in indoor air in ten laboratories and three offices at the University of Iowa. One to ten people occupy each of these spaces during daytime work hours. D4 concentrations ranged from 23 to 500 ng/m^3 . The authors hypothesized that the personal care product is the likely source of cyclic siloxanes in these sampled indoor air environments. Personal care products classified as cosmetics are outside of EPA's jurisdiction.

Overall, measured concentrations of D4 in indoor air were low and background levels during unoccupied periods indicate potential contributions from continuous sources, though uncertainty remains regarding specific contributors. However, use of personal care products was identified as a key source of D4 in indoor air, with rapid dissipation leading to transient peaks rather than sustained elevations. Modeled air concentration values for this assessment (0.04–40,000 $\mu\text{g}/\text{m}^3$) were substantially higher than measured concentrations in any study. Given the rapid dissipation time of D4 in air, episodic spikes in D4 air concentration would not be captured in measurement studies unless products were actively in use during the sampling period. In addition, limitations in study design, including small sample sizes, lack of metadata on product use, and variability in sampling conditions further complicate interpretation of measured concentrations. As such, a direct comparison between modeled and measured D4 concentrations is not likely to be meaningful.

5 WEIGHT OF SCIENTIFIC EVIDENCE

5.1 Consumer Exposure Analysis Weight of Scientific Evidence

Variability and uncertainty are two key elements in evaluating the weight of scientific evidence.

Variability refers to the inherent heterogeneity or diversity of data in an assessment. It is a description of the range or spread of a set of values. Uncertainty refers to a lack of data or an incomplete understanding of the context of the risk evaluation decision. Variability cannot be reduced, but it can be better characterized while uncertainty can be reduced by collecting more or better data. Uncertainty also can be addressed qualitatively by including a discussion of factors such as data gaps and subjective decisions or instances where professional judgment was used. Uncertainties associated with approaches and data used in the evaluation of consumer exposures are described below.

The exposure assessment of chemicals from consumer products and articles has inherent challenges due to many sources of uncertainty in the analysis, including variations in product formulation, patterns of consumer use, frequency and duration of use, and product application methods. Variability in environmental conditions may also alter physical and/or chemical behavior of the product or article. Key sources of uncertainty for evaluating exposure to D4 in consumer goods and strategies to address those uncertainties are described in this section.

Generally, designation of robust confidence suggests thorough understanding of the scientific evidence and uncertainties. The supporting weight of scientific evidence outweighs the uncertainties to the point where it is unlikely that the uncertainties could have a significant effect on the exposure estimate. The designation of moderate confidence suggests some understanding of the scientific evidence and uncertainties. More specifically, the supporting scientific evidence weighed against the uncertainties is reasonably adequate to characterize exposure estimates, but there are some unknowns. The designation of slight confidence is assigned when the weight of scientific evidence may not be adequate to characterize the scenario, and when the assessor is making the best scientific assessment possible in the absence of complete information and there are additional unknown uncertainties that may need to be considered. Table 5-1 summarizes the overall uncertainty per COU, and a discussion of rationale used to assign the overall uncertainty. The subsections ahead of the table describe sources of uncertainty for several parameters used in consumer exposure modeling that apply across COUs and provide an in depth understanding of sources of uncertainty and limitations and strengths within the analysis. The confidence to use the results for risk characterization ranges from moderate to robust (Table 5-1). The basis for the moderate to robust confidence in the overall exposure estimates is a balance between using parameters that will represent various populations, use patterns, and lean on protective assumptions that are not outliers, excessive, or unreasonable.

Product Formulation and Composition

Variability in the formulation of consumer products, including changes in ingredients, concentrations, and chemical forms can introduce uncertainty in exposure assessments. In this assessment, data were sometimes limited for weight fractions of D4 in consumer goods. EPA obtained D4 weight fractions in various products and articles from material safety sheets, databases, and existing literature (see Section 2.1). Where possible, EPA obtained multiple values for weight fractions for similar products or articles. The lowest value was used in the low exposure scenario, the highest value in the high exposure scenario, and the average of all values in the medium exposure scenario. EPA decreased uncertainty in exposure and subsequent risk estimates in the low-, medium-, and high-intensity use scenarios by capturing the weight fraction variability and better characterizing the varying composition of products and articles within one COU. Overall weight fraction confidence was robust for products/articles with more than one

source, moderate for products/articles with multiple sources but insufficient description on how the concentrations were obtained, and slight for products/articles with only one source and unconfirmed content or little understanding on how the information was produced.

For the laundry and dishwashing COU, no SDS were identified. The only SDSs were for a single company's antifoam formulation and another company's PDMS composition. Various types of laundry detergent are on the market. While it is reasonable to assume that many contain antifoam to reduce or prevent foam formation, it is less appropriate to postulate that all contain the same antifoam. PDMS polymers added to antifoam agents can also vary between producers. The wide disparity between SEHSC's 1 to 5 percent range and the estimated 0.015 percent weight fraction also leads to greater uncertainties. In the absence of additional information, EPA cannot determine which source(s) provide more representative weight fractions. EPA has only slight confidence in the weight fractions and calculated exposure estimates for all intensity use scenarios. These values were thus not used to characterize consumer risks from use of laundry detergent.

Product Use Patterns

Consumer use patterns such as frequency of use, duration of use, methods of application, and skin contact area are expected to differ. Where possible, low, medium, and high default values from CEM 3.2's prepopulated scenarios were selected for mass of product used, duration of use, and frequency of use. In instances where no prepopulated scenario was appropriate for a specific product, low, medium, and high values for each of these parameters were estimated based on reported values for frequency and mass of similar products used found in the *Exposure Factors Handbook*. EPA decreased uncertainty by selecting use pattern inputs that represent product and article use descriptions and furthermore capture the range of possible use patterns in the high to low-intensity use scenarios. Exposure and risk estimates are considered representative of product use patterns and well characterized. Most use patterns overall confidence was rated robust.

Article Surface Area

The surface area of an article directly affects the potential for D4 emissions to the environment. For bedding material modeled for inhalation exposure, low, medium, and high estimates for surface area were calculated (Section 2.3). This approach relied on manufacturer-provided dimensions across multiple retailers. Overall confidence in surface area is robust because these items are standardized in size, and there is a good understanding of the presence and dimensions in indoor environments.

Human Behavior

CEM 3.2 has three different activity patterns: (1) stay-at-home, (2) part-time out-of-the home (daycare, school, or work), and (3) full-time out-of-the-home. The activity patterns were developed based on the Consolidated Human Activity Database. For all products and articles modeled, the stay-at-home activity pattern was chosen as it is the most conservative assumption and confidence is considered robust.

Mouthing durations are a source of uncertainty in human behavior. The data used in this assessment were based on a study in which parents observed children (n = 236) aged 1 month to 5 years for 15 minutes each session and 20 sessions in total ([Smith and Norris, 2003](#)). There was considerable variability in the data due to behavioral differences among children of the same lifestage. For instance, while children aged 6 to 9 months had the highest average mouthing duration for toys at 39 minutes per day, the minimum duration was zero and the maximum was 227 minutes per day. The observers noted that the items mouthed were made of plastic roughly 50 percent of the mouthing time, but this was not limited to soft silicone plastic items likely to contain significant D4 content. In another study, 169 children aged 3 months to 3 years were monitored by trained observers for 12 sessions at 12 minutes

each ([Greene, 2002](#)). They reported mean mouthing durations ranging from 0.8 to 1.3 minutes per day for soft plastic toys and 3.8 to 4.4 minutes per day for other soft plastic objects (except pacifiers). EPA assigned a moderate confidence associated with the duration of activity for mouthing because the magnitude of the overestimation is not well characterized. All other human behavior parameters are well understood, or the ranges used capture use patterns representative of various lifestages, which results in a robust confidence in use patterns.

Modeling Tools

Confidence in the modeling tools considers whether the model has been peer-reviewed and whether they are being applied in a manner appropriate to its design and objective. The models used (CEM 3.2 and IECCU 1.1) have been peer-reviewed, are publicly available, and have been applied in their intended manner to estimate exposures associated with uses of household products and/or articles. Default model such as building and room volumes, interzonal ventilation rates, and air exchange rates were also used when appropriate. Overall confidence in the proper use of CEM and IECCU for consumer exposure modeling is robust. For modeling done outside of CEM and IECCU (dermal and mouthing exposure), the underlying methodologies were based on the same methods used in CEM but were modified to not assume 100 percent dermal absorption for compatibility with benchmark dose derivation. As such, these were also considered robust.

Dermal Modeling for D4

Experimental data for dermal uptake of D4 from consumer products was identified via the systematic review process to characterize dermal exposures to liquids or mixtures and formulations containing D4. The information was used to calculate BMD values using a PBPK model, incorporating study data obtained under unoccluded conditions. Given D4's volatility, significant vaporization from the skin is expected, reducing systemic absorption compared to scenarios where volatilization is restricted. The PBPK model explicitly accounted for this process by integrating dermal absorption and volatilization kinetics, which provides an accurate representation of the bioavailable fraction. Because the BMD values were derived based on external dose-effect relationships, they inherently reflect the influence of volatilization, ensuring their relevance for real-world exposure conditions. Confidence in these dermal models is robust due to the well-characterized nature of dermal absorption kinetics, extensive empirical data supporting model parameterization, and validation studies demonstrating their ability to reliably predict internal doses across different exposure scenarios.

To estimate dermal loading from solid articles, a diffusion-based model was used, which accounts for chemical migration from the solid matrix. Uncertainties in this approach include factors such as variability in material properties, concentration depletion effects, and potential differences in dermal absorption kinetics compared to liquids. In addition, BMD values derived from dermal exposure to D4 in liquid products were also used to assess exposure from solid articles. A key concern in applying BMD values from liquid exposures to solid articles is the potential impact of liquid formulations on skin structure. Liquids can alter skin barrier properties by enhancing hydration, disrupting lipid organization, or acting as solvents for the chemical, which may increase dermal penetration. These effects are not typically present with solid articles, meaning that BMD values derived from liquid exposure scenarios may not accurately reflect absorption dynamics from solid matrices. If the liquid phase of a product significantly influences skin permeability, the systemic dose from solid exposures may be overestimated or underestimated depending on the extent of these effects. Further, the BMD values relied on dermal absorption parameters appropriate for unoccluded conditions, but a BMD was estimated for occluded scenarios as explained in *Draft Human Health Hazard Assessment for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025f](#)). Occluded scenarios can occur for solid articles that act as a barrier to chemical migration away from the skin such as clothing and bedding. Use of a BMD for occluded scenarios

reduces the potential for underestimating risks from scenarios where a barrier may restrict D4 evaporation. Confidence in these dermal models is moderate due to a higher degree of uncertainty as compared to liquid products.

Ingestion Via Mouthing Modeling Parameters for D4 Chemical Migration

For chemical migration rates to saliva, no empirical data were identified during systematic review. Existing data were highly variable both within and between studies. A theoretical framework based on physical and chemical properties of D4 and the solid matrix material was used to estimate chemical migration rates in the absence of adequate empirical data. This model was internally and externally validated against measured diffusion coefficients and shown to have good predictive capability for chemicals with molecular weights between 30 and 1,178 g/mol at temperatures between 4 and 180 °C ([Aurisano et al., 2022](#)), which are well within D4 properties and temperatures during product use. There are uncertainties in the estimated chemical migration rate because it may differ among items due to variations in chemical makeup and matrix structure. EPA has a moderate confidence in the chemical migration rate value in the context of consumer product considerations and a moderate confidence in the overall modeling approach when considering the moderate confidence in the mouthing durations and other modeling inputs.

Table 5-1. Weight of Scientific Evidence Summary per Consumer COU

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
Adhesives and sealants	One scenario was assessed under this COU for eight product types with differing use patterns which are expected to be captured in low-, medium-, and high-intensity exposure estimates. The confidence in the weight fractions is robust because all eight products had SDSs for this parameter. The overall confidence in this COU's inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. For dermal exposure EPA used a thin-film model. An overall robust confidence in dermal assessment of adhesives was assigned because dermal absorption is well characterized and accounted for via a PBPK model and the subsequent predicted dermal HEDs that were used to characterize risk. In addition, other parameters such as frequency and duration of use, and surface area in contact are well understood and representative, resulting in an overall confidence of robust.	Inhalation and dermal – Robust
Automotive care products	One scenario was assessed under this COU for 10 product types with differing use patterns which are expected to be captured in low-, medium-, and high-intensity exposure estimates. The confidence in the weight fractions is robust because all 10 products had SDSs for this parameter. The overall confidence in this COU inhalation exposure estimate is robust because the CEM default parameters represent actual use patterns and location of use. For dermal exposure, EPA used a thin-film model. An overall robust confidence in dermal assessment of automotive care products was assigned because dermal absorption is well characterized and accounted for in BMD values via a PBPK model, which were used to characterize risk. In addition, other parameters such as frequency and	Inhalation and dermal – Robust

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	duration of use, and surface area in contact are well understood and representative, resulting in an overall confidence of robust.	
Furnishing, cleaning, treatment/care products – Cleaning and furnishing care products and fabric, textile, and leather products not covered elsewhere	One scenario was assessed under this COU for two known product types, and weight fractions of D4 in cleaning products reported in literature without specific identification of products were also incorporated. The confidence in the weight fractions is moderate because not all of the products had SDSs reporting weight fractions. In those instances, EPA used a human health risk assessment for spray products provided by the SEHSC (Exponent, 2024). The overall confidence in this COU's inhalation exposure estimate is moderate because there is some uncertainty about specific kinds of products with D4 content, so it is unclear if CEM default parameters represent actual use patterns and location of use. For dermal exposure EPA used a thin-film model. An overall robust confidence in dermal assessment of furnishing, cleaning, treatment/care products was assigned because dermal absorption is well characterized and accounted for via a PBPK model, which were used to characterize risk. However, other parameters such as frequency and duration of use, and surface area in contact, are not as well understood due to uncertainties about specific products with D4 content, resulting in an overall confidence of moderate.	Inhalation and dermal – Moderate
Furnishing, cleaning, treatment/care products – Laundry and dishwashing products	One scenario was assessed under this COU, but EPA did not identify any specific products. Laundry detergent can contain D4 because of the addition of antifoaming agents. The specific antifoam in detergents is unknown. One SDS reported an antifoam in detergent containing a specific PDMS polymer which did specify the D4 content. However, the antifoam and the PDMS polymer can vary between detergent, and thus the weight fraction is expected to differ as well. EPA also considered the weight fractions provided by ACC SEHSC that is broadly relevant to a wide array of commercial and consumer products that includes laundry detergent. The weight fractions vary up to two orders of magnitude between the two sources. As such, EPA has a high level of uncertainty about the D4 content in laundry detergent. Other parameters, such as frequency, duration, and mass used are based on CEM defaults and represent actual use patterns. Overall confidence in the exposure estimates is still slight because weight fraction is a key driver of inhalation exposure estimates.	Inhalation – Slight
Other – Animal grooming products	Animal grooming products with D4 content were reported in an exposure assessment provided by ACC SEHSC, but no specific products were identified by EPA. One scenario was assessed under this COU using D4 weight fractions reported by ACC SEHSC. The overall confidence in this COU inhalation exposure estimate is moderate due to the high level of uncertainty about specific kinds of products with D4 content. It is unclear if CEM default parameters represent actual use patterns and location of use.	Inhalation and dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	For dermal exposure EPA used a thin-film model. An overall moderate confidence in dermal assessment of animal grooming products was assigned. Dermal absorption is well characterized and accounted for in BMD values via a PBPK model, which were used to characterize risk. Other parameters, such as frequency and duration of use, and surface area in contact, are not as well understood due to uncertainties about specific products with D4 content, resulting in an overall confidence of moderate.	
Packaging, paper, plastic, hobby products; plastic and rubber products not covered elsewhere	Two scenarios were assessed under this COU for articles with differing use patterns: 1) plastic and rubber items meant to be mouthed which were modeled for ingestion by mouthing and 2) rubber shoe components which were modeled for dermal exposure. The overall confidence in assessment of this COU for ingestion from mouthing exposure is moderate. The confidence in the weight fractions is moderate. While EPA relied on two databases from Washington and Oregon state that have limitations as presented in Section 2.1.1 of U.S. EPA (2025a), there multiple articles with concentration data. The mouthing parameters used like duration and surface area for infants to children are very well understood. However, the chemical migration value could not be validated against real world observations and may not fully account for variability in product formulation. To estimate surface concentration at the skin, a diffusion-based model was used, which accounts for chemical migration from the solid matrix. Overall, EPA has moderate confidence in the dermal assessment. The solid-phase diffusion coefficients and solid-air partitioning coefficients were based on well-validated chemical and material-specific models, but the values could not be verified with empirical data. The variability in skin surface properties (<i>e.g.</i>, hydration, temperature) may also affect accuracy. Lastly, models do not account for chemical depletion from the assessed articles over time and thus can overestimate chronic exposure. However, uncertainties with the above parameters are balanced by parameters that are well understood and representative. These include the frequency and duration of use and surface area in contact with these items.	Ingestion by mouthing – Moderate Dermal – Moderate
Packaging, paper, plastic, hobby products; toys, playground, and sporting equipment	Three different scenarios were assessed under this COU for various articles with differing use patterns: 1) fabric and textile toys, 2) plastic and rubber toys, and 3) putties and other viscoelastic polymer toys. The primary data source for this COU was manufacturer disclosed D4 content in items reported to the High Production Chemical Data System (HPCDS). There is inherent uncertainty in interpreting specific items reported in HPCDS due to its generalized reporting structure, which often categorizes items by broad categories rather than specific product. This lack of specificity complicates exposure assessments, as the physical and chemical characteristics of a given product can significantly influence chemical migration and human	Ingestion by mouthing – Moderate Dermal – Moderate

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
	contact. However, cross-referencing with the Vermont Brands database, which identifies consumer products with D4 content reported by specific manufacturers, improved confidence that the scenarios were appropriately representative. Plastic and rubber as well as fabric and textile toys were assessed for mouthing and dermal contact, while putties and other viscoelastic polymer toys were assessed only for dermal contact. The low-, medium-, and high-intensity scenarios capture variability and provide a range of representative use patterns. The overall confidence in assessment of this COU for ingestion from mouthing exposure is moderate. The mouthing parameters used like duration and surface area for infants to children are very well understood. However, the chemical migration value could not be validated against real world observations and may not fully account for variability in product formulation. To estimate surface concentration at the skin, a diffusion-based model was used, which accounts for chemical migration from the solid matrix. Overall, EPA has moderate confidence in the dermal assessment. The solid-phase diffusion coefficients and solid-air partitioning coefficients were based on well-validated chemical and material-specific models, but the values could not be verified with empirical data. The variability in skin surface properties (<i>e.g.</i>, hydration, temperature) may also affect accuracy. Lastly, models do not account for chemical depletion from the assessed articles over time and thus can overestimate chronic exposure. However, uncertainties with the above parameters are balanced by parameters that are reasonably understood and representative. These include the frequency and duration of use and surface area in contact with viscoelastic polymer toys.	
Paints and coatings	Two different scenarios were assessed under this COU for products with differing use patterns. The confidence in the weight fractions is robust because all products had SDSs for this parameter. The two scenarios and the products associated with them capture the variability in product formulation and are represented in the low-, medium-, and high-intensity use estimates. The overall confidence in this COU inhalation exposure estimate is robust because these product types have well characterized use pattern data available which were aligned with observations in consumer reviews at online retailer sites. An overall robust confidence in dermal assessment of paints and coatings was assigned. Dermal absorption is well characterized and accounted for in BMD values via a PBPK model, which were used to characterize risk. In addition, other parameters such as frequency and duration of use and surface area in contact are well understood and representative, resulting in an overall robust confidence in the exposure estimates.	Inhalation and dermal – Robust

Consumer COU Category and Subcategory	Weight of Scientific Evidence	Overall Confidence
Textiles and apparel	Two different scenarios were assessed under this COU for articles with differing use patterns: bedding and clothing. Both items were assessed for dermal exposure; due to the large surface area of the item, bedding was assessed for inhalation exposure as well. The confidence in the weight fractions is moderate. While EPA relied on two databases from Washington and Oregon state that have limitations as presented in Section 2.1.1 of U.S. EPA (2025a), there were many articles with weight fraction data. The overall confidence in the bedding inhalation exposure estimate is still robust because the physical properties and use patterns of these items was well understood, mitigating some of the uncertainties from the weight fraction. To estimate surface concentration at the skin, a diffusion-based model was used, which accounts for chemical migration from the solid matrix. Overall, EPA has moderate confidence in the dermal assessment. The solid-phase diffusion coefficients and solid-air partitioning coefficients were based on well-validated chemical and material-specific models, but the values could not be verified with empirical data. The variability in skin surface properties (<i>e.g.</i>, hydration, temperature) may also affect accuracy. Lastly, models do not account for chemical depletion from the assess article over time and thus can overestimate chronic exposure. However, uncertainties with the above parameters are balanced by parameters that are well understood and representative. These include the frequency and duration of use and surface area in contact with bedding and clothing.	Inhalation – Robust Dermal – Moderate

1682

6 STEPS TOWARDS RISK CHARACTERIZATION

All COU exposure dose results summarized in Section 3 have a moderate to robust confidence, except for inhalation exposure for laundry detergent which had slight confidence. Exposure estimates for laundry detergent were not used to characterize risks because of the high level of uncertainties. For all other consumer COUs, the consumer assessment has low, medium, and high exposure scenarios which represent use patterns of low-, medium-, and high-intensity uses. The high exposure scenarios capture use patterns for high exposure potential from high frequency, mass, and duration of use, extensive mouthing, and conditions that promote greater migration of D4 from products/articles to sweat and skin. Low and medium exposure scenarios represent lesser intensity in use patterns, mouthing behaviors, and conditions that promote D4 migration to sweat and skin, capturing populations with different lifestyles. The application of these exposure estimates for risk characterization in various lifestages can be found in the *Draft Risk Evaluation for Octamethylcyclotetrasiloxane (D4)* ([U.S. EPA, 2025h](#)).

REFERENCES

- 3M. (2018). Safety Data Sheet (SDS): 3M™ Super Silicone Sealant (Clear), 08661, 08663. St. Paul, MN.
https://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSuUn_zu8l00xmx_1n8_env70k17zHvu9lxtD7SSSSSS--
- 3M. (2020). Safety Data Sheet (SDS): 3M™ Waterless Wash & Wax, 39110. St. Paul, MN.
https://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSuUn_zu8l00xm8telx_Bov70k17zHvu9lxtD7SSSSSS--
- 3M. (2024). Safety Data Sheet (SDS): 3M™ Marine Silicone Sealant - White, P.N. 08017, 08027. St. Paul, MN.
https://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSuUn_zu8l00xl8m1o8_Bnv70k17zHvu9lxtD7SSSSSS--
- Aurisano, N; Fantke, P; Huang, L; Jolliet, O. (2022). Estimating mouthing exposure to chemicals in children's products. J Expo Sci Environ Epidemiol 32: 94-102. <http://dx.doi.org/10.1038/s41370-021-00354-0>
- Benjamin Moore. (2024). Safety Data Sheet (SDS): WOODLUXE OIL-BASED WATERPROOFING STAIN & SEALER TRANSLUCENT - TEAK. Montvale, NJ.
https://media.benjaminmoore.com/WebServices/prod/assets/production/datasheets/MSDS_0591/C59130_SDS_EN.pdf
- Brooke, DN; Crookes, MJ; Gray, D; Robertson, S. (2009). Environmental risk assessment report: Octamethylcyclotetrasiloxane. Bristol, UK: UK Environmental Agency.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/290565/scho0309bpqz-e-e.pdf
- C.R. Laurence. (2019). Safety Data Sheet (SDS): CRL848 Plastic Cleaner. Los Angeles, CA.
https://webcache.crlaurence.com/DataSheets/MSDS/PDF_COM/CRL848.pdf
- CDC. (2021). Child development: Positive parenting tips. Available online at <https://www.cdc.gov/ncbddd/childdevelopment/positiveparenting/index.html> (accessed April 3, 2024).
- Chen, L; Tang, Y; Zhao, K; Zha, X; Liu, J; Bai, H; Wu, Z. (2019). Fabrication of the antibiotic-releasing gelatin/PMMA bone cement. Colloids Surf B Biointerfaces 183.
<http://dx.doi.org/10.1016/j.colsurfb.2019.110448>
- Delmaar, JE; Bokkers, BG; Ter Burg, W; Van Engelen, JG. (2013). First tier modeling of consumer dermal exposure to substances in consumer articles under REACH: A quantitative evaluation of the ECETOC TRA for consumers tool. Regul Toxicol Pharmacol 65: 79-86.
<http://dx.doi.org/10.1016/j.yrtph.2012.10.015>
- Dow Chemical. (2022). Safety Data Sheet (SDS): DOWSIL™ AF-8014 Antifoam. Midland, MI.
<https://www.dow.com/en-us/pdp.dowsil-af-8014-antifoam.04125586z.html#overview>
- Dow Corning. (2017). Safety Data Sheet (SDS): DOWSIL™ 890-SL Silicone Joint Sealant. Midland, MI. <https://www.dow.com/en-us/pdp.dowsil-890-sl-silicone-joint-sealant.04105659h.html#tech-content>
- Dow Corning. (2022). Safety Data Sheet (SDS): Molykote 111 Compound. Midland, MI.
https://cdn.pasco.com/product_document/TD-8577-SDS-Dow-Corning-111-Valve-Lub-and-Sealant.pdf
- ERG. (2016). Peer review of EPA's Consumer Exposure Model and draft user guide (final peer review report). Washington, DC: U.S. Environmental Protection Agency.
- ERM. (2017a). D4 environmental testing report, Enforceable Consent Agreement (ECA): Testing consent order for octamethylcyclotetrasiloxane (D4), CASRN: 556-67-2, volume 1 of 2, text, figures, tables, and appendices A through J. (Docket No. EPA-HQ-OPPT-2012-0209).

- Washington, DC: American Chemistry Council and Silicones Environmental, Health, and Safety Center. <https://www.regulations.gov/document?D=EPA-HQ-OPPT-2012-0209-0117>
- [ERM](#). (2017b). D4 environmental testing report, Enforceable Consent Agreement (ECA): Testing consent order for octamethylcyclotetrasiloxane (D4), CASRN: 556-67-2, volume 2 of 2, appendices K through ZA. (Docket No. EPA-HQ-OPPT-2012-0209). Washington, DC: American Chemistry Council and Silicones Environmental, Health, and Safety Center. <https://www.regulations.gov/document/EPA-HQ-OPPT-2012-0209-0121>
- [Exponent, Inc.,](#) . (2024). Memo from Exponent to SEHSC: SEHSC D4 Human Health Aerosol Risk Assessment for Formulations with cover letter dated 02/23/2024. (2203904.000). Washington, DC: Silicones Environmental, Health, and Safety Center.
- [Faultless](#). (2019). Safety Data Sheet (SDS): Niagara Fabric Finish Spray Sizing. Kansas City, MO. <https://corporate.faultless.com/SDSfiles/Niagara%20Starch%20Products/Niagara%20Fabric%20Finish%20Spray%20Sizing.pdf>
- [Gelest](#). (2025). Safety Data Sheet (SDS): Polydimethylsiloxane, Trimethylsiloxy Terminated (DMS-T07). Morrisville, PA: Gelest, Inc. <https://www.gelest.com/product/DMS-T07/>
- [Greene, MA](#). (2002). Mouthing times among young children from observational data. Bethesda, MD: U.S. Consumer Product Safety Commission.
- [Horii, Y; Kannan, K](#). (2008). Survey of Organosilicone Compounds, Including Cyclic and Linear Siloxanes, in Personal-Care and Household Products. Arch Environ Contam Toxicol 55: 701-710. <http://dx.doi.org/10.1007/s00244-008-9172-z>
- [Huang, L; Fantke, P; Ernstoff, A; Jolliet, OA](#). (2017). Quantitative property-property relationship for the internal diffusion coefficients of organic compounds in solid materials. Indoor Air 27: 1128-1140. <http://dx.doi.org/10.1111/ina.12395>
- [Huang, L; Jolliet, O](#). (2019). A quantitative structure-property relationship (QSPR) for estimating solid material-air partition coefficients of organic compounds. Indoor Air 29: 79-88. <http://dx.doi.org/10.1111/ina.12510>
- [ITW Global Brands](#). (2021a). Safety Data Sheet (SDS): Black Magic Tire Wet Spray (BC23220; BC23220W; BC23220ES). Houston, TX. <https://www.blackmagicshine.com/wp-content/uploads/2022/04/BC23220-Black-Magic-Tire-Wet-Spray-03232021.pdf>
- [ITW Global Brands](#). (2021b). Safety Data Sheet (SDS): Rain-X Pro Graphene Spray Wax. Houston, TX. <https://www.rainx.com/wp-content/uploads/2020/11/620186-620184SRP-Rain-X-Pro-Graphene-Spray-Wax-06242021.pdf>
- [Jax Wax](#). (2018). Safety Data Sheet (SDS): Jax Wax Spray and Seal. Columbus, OH. <https://jaxautowax.com.au/wp-content/uploads/2020/09/Spray-N-Seal-SDS-1.pdf>
- [Liu, N; Xu, L; Cai, Y](#). (2017). Methyl siloxanes in barbershops and residence indoor dust and the implication for human exposures. Sci Total Environ 618: 1324-1330. <http://dx.doi.org/10.1016/j.scitotenv.2017.09.250>
- [Lu, Y; Yuan, T; Yun, S; Wang, W; Wu, Q; Kannan, K](#). (2010). Occurrence of Cyclic and Linear Siloxanes in Indoor Dust from China, and Implications for Human Exposures. Environ Sci Technol 44: 6081-6087. <http://dx.doi.org/10.1021/es101368n>
- [Molinier, B; Arata, C; Katz, EF; Lunderberg, DM; Liu, Y; Misztal, PK; Nazaroff, WW; Goldstein, AH](#). (2022). Volatile methyl siloxanes and other organosilicon compounds in residential air. Environ Sci Technol 56: 15427-15436. <http://dx.doi.org/10.1021/acs.est.2c05438>
- [Momentive](#). (2017). Safety Data Sheet (SDS): RTV102 (White). New Smyrna Beach, FL: Momentive Performance Materials - Daytona. <https://static.rshughes.com/wm/p/wm-asis/75c60f4ce94e60a44ff8ceca03e2e88a34028d10.pdf?uf=>
- [Momentive](#). (2019). Safety Data Sheet (SDS): SAG TP-735. Niskayuna, NY.
- [Mothers](#). (2018). Safety Data Sheet (SDS): Mothers CMX Spray. Huntington Beach, CA. <https://www.autowaresgroup.com/msds/Mothers%20Wax/01024.pdf>

- Nuco. (2021). Safety Data Sheet (SDS): Nuflex® 302 GP- Clear. Guelph, Ontario, CN. https://nuco-uploads.s3.amazonaws.com/uploads/pdfs/Nuflex_302_GP_Clear_SlyyBMI.pdf
- OECD. (2019). Estimating mouthing exposure in children-compilation of case studies. (ENV/JM/MONO(2019)24; JT03449943). Paris, France. [http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV-JM-MONO\(2019\)24%20&doclanguage=en](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV-JM-MONO(2019)24%20&doclanguage=en)
- Oil-Chem Research Corporation. (2019). Safety Data Sheet (SDS): ZMAX Spray Wax (2625). Harrisburg, NC. <https://www.spartanchemical.com/sds/downloads/AGHS/EN/2625.pdf>
- Old Masters. (2020). Safety Data Sheet (SDS): Low VOC Wood Conditioner. Orange City, IA. <https://myoldmasters.com/documents/old-masters-wood-conditioner-51101-sds-en>
- P&G. (2025). Tide Detergent Ingredients A-Z. Available online at <https://tide.com/en-us/our-commitment/ingredients-and-safety/tide-detergent-ingredients-a-to-z> (accessed June 5, 2025).
- RJ Star. (2016). Safety Data Sheet (SDS): Wizards Mystic Spray Wax. Hanover, MN: RJ Star, Inc. dba Wizards Products. https://cdn.shopify.com/s/files/1/0084/3461/4335/files/SDS_for_Mystic_Nano_Wax.pdf?v=1713880461
- RSC. (2020). ChemSpider: Octamethylcyclotetrasiloxane. Available online at <http://www.chemspider.com/Chemical-Structure.10696.html?rid=3055cfe0-a40c-4a12-9d35-a7d3667df89d>
- Rust-Oleum. (2023a). Safety Data Sheet (SDS): PRO 1-GL 2PK GLOSS LEATHER BROWN 100VOC (High Performance Protective Enamel Gloss Leather Brown Oil-Based Interior/Exterior Metal Paint). Vernon Hills, IL. <https://ace.infotrac.net/getmsds.aspx?sku=1396357>
- Rust-Oleum. (2023b). Safety Data Sheet (SDS): WOLMAN 1-GL 4 PK RAINCOAT OIL BASE. Vernon Hills, IL. <https://www.rustoleum.com/MSDS/ENGLISH/12386.PDF>
- SAF-T-LOK. (2018). Safety Data Sheet (SDS): RTV Silicone Clear (RTV 732). Lombard, IL. https://www.saftlok.com/stl/msds/MSDS-RTV732_Clear_Silicone_Sealant.pdf
- SEHSC. (2020). Request for risk evaluation under the Toxic Substances Control Act; Octamethylcyclotetrasiloxane (D4; CASRN: 556-67-2). Washington, DC: American Chemistry Council. https://www.epa.gov/sites/production/files/2020-04/documents/d4_mrre_dossier_28jan2020_1.pdf
- Shields, HC; Fleischer, DM; Weschler, CJ. (1996). Comparisons among VOCs measured in three types of US commercial buildings with different occupant densities. Indoor Air 6: 2-17. <http://dx.doi.org/10.1111/j.1600-0668.1996.t01-3-00002.x>
- Silco Inc. (2015). Safety Data Sheet (SDS): SIL-BOND RTV 4500. Mentor, OH. https://www.natconusa.com/wp-content/uploads/2020/04/SILCO_SDS-RTV-4500.pdf
- Smith, SA; Norris, B. (2003). Reducing the risk of choking hazards: Mouthing behaviour of children aged 1 month to 5 years. Inj Contr Saf Promot 10: 145-154. <http://dx.doi.org/10.1076/icsp.10.3.145.14562>
- Spartan Chemicals. (2015). Safety Data Sheet (SDS): Shine Plus. Maumee, OH. <https://www.greatwesternsupply.com/PDF/SDS/SHINE%20PLUS.PDF>
- Sprayway. (2020). Safety Data Sheet (SDS): Penetrant, Lubricant, Demoisturant, Protectant - SW450. Pacific, MO: Sprayway, Inc. <https://www.spraywayinc.com/sites/all/themes/theme687/msds/sw450.pdf>
- Surf City Garage. (2015a). Safety Data Sheet (SDS): Black Edge Spray Wax. Huntington Beach, CA. https://www.globalindustrial.com/site/images/SurfCityGaragePdfs/925-SDS-Black_Edge_Spray_Wax-US-en.pdf?msocid=313922b5b35364451c0436c2b201657c
- Surf City Garage. (2015b). Safety Data Sheet (SDS): Surf City Garage Speed Demon. Huntington Beach, CA. https://www.globalindustrial.com/site/images/SurfCityGaragePdfs/100-SDS-Surf_City_Garage_Speed_Demon-US-en.pdf?msocid=313922b5b35364451c0436c2b201657c

- [Tang, X; Misztal, PK; Nazaroff, WW; Goldstein, AH.](#) (2015). Siloxanes are the most abundant volatile organic compound emitted from engineering students in a classroom. *Environ Sci Technol Lett* 2: 303-307. <http://dx.doi.org/10.1021/acs.estlett.5b00256>
- [TCC.](#) (2017). Safety Data Sheet (SDS): JOHNSEN'S DOT 5 BRAKE FLUID 32 FL.OZ. Cleburne, TX. <https://www.johnsens.com/all/7032-dot-5-brake-fluid/>
- [Tran, TM; Abualnaja, KO; Asimakopoulous, AG; Covaci, A; Gevao, B; Johnson-Restrepo, B; Kumosani, TA; Malarvannan, G; Minh, TB; Moon, HB; Nakata, H; Sinha, RK; Kannan, K.](#) (2015). A survey of cyclic and linear siloxanes in indoor dust and their implications for human exposures in twelve countries. *Environ Int* 78: 39-44. <http://dx.doi.org/10.1016/j.envint.2015.02.011>
- [Tran, TM; Kannan, K.](#) (2015). Occurrence of cyclic and linear siloxanes in indoor air from Albany, New York, USA, and its implications for inhalation exposure. *Sci Total Environ* 511: 138-144. <http://dx.doi.org/10.1016/j.scitotenv.2014.12.022>
- [Turtle Wax Limited.](#) (2020). Safety Data Sheet (SDS): Hybrid Solutions Ceramic Acrylic Black Wax. Addison, IL. https://www.whatsinproducts.com/app/webroot/files/brands_pdf/1610588688.pdf
- [U.S. EPA.](#) (2006). A framework for assessing health risk of environmental exposures to children. (EPA/600/R-05/093F). Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=158363>
- [U.S. EPA.](#) (2007). Dermal exposure assessment: A summary of EPA approaches [EPA Report]. (EPA/600/R-07/040F). Washington, DC. <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=183584>
- [U.S. EPA.](#) (2011a). Exposure Factors Handbook, Chapter 6: Inhalation rates. Washington, DC. <https://www.epa.gov/expobox/exposure-factors-handbook-chapter-6>
- [U.S. EPA.](#) (2011b). Exposure factors handbook: 2011 edition [EPA Report]. (EPA/600/R-090/052F). Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. <https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockkey=P100F2OS.txt>
- [U.S. EPA.](#) (2019). IECCU 1.1 User's Guide. In Simulation Program for Estimating Chemical Emissions from Sources and Related Changes to Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones (IECCU). (EPA Contract # EP-W-12-010). Washington, DC: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics.
- [U.S. EPA.](#) (2020). 2020 CDR data [Database]. Washington, DC: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics. Retrieved from <https://www.epa.gov/chemical-data-reporting/access-cdr-data>
- [U.S. EPA.](#) (2021). Use Report for Octamethylcyclotetra- siloxane (Cyclotetrasiloxane, 2,2,4,4,6,6,8,8-octamethyl-) (D4) CASRN 556-67-2. Washington, DC: Office of Chemical Safety and Pollution Prevention. <https://www.regulations.gov/document/EPA-HQ-OPPT-2018-0443-0023>
- [U.S. EPA.](#) (2022). Final scope of the risk evaluation for octamethylcyclotetrasiloxane (Cyclotetrasiloxane, 2,2,4,4,6,6,8,8-octamethyl-) (D4); CASRN 556-67-2. (EPA 740-R-21-003). Washington, DC: Office of Chemical Safety and Pollution Prevention. https://www.epa.gov/system/files/documents/2022-03/casrn_556_67_2-octamethylcyclotetra-siloxane-d4_finalscope.pdf
- [U.S. EPA.](#) (2023). Consumer Exposure Model (CEM) Version 3.2 User's Guide. Washington, DC. <https://www.epa.gov/tsca-screening-tools/consumer-exposure-model-cem-version-32-users-guide>
- [U.S. EPA.](#) (2025a). Draft Consumer and Indoor Exposure Assessment for Octamethylcyclotetrasiloxane (D4). Washington, DC: Office of Pollution Prevention and Toxics.
- [U.S. EPA.](#) (2025b). Draft Consumer Exposure Analysis for Octamethylcyclotetrasiloxane (D4). Washington, DC: Office of Pollution Prevention and Toxics.

1890 [U.S. EPA.](#) (2025c). Draft Consumer Risk Calculator for Octamethylcyclotetrasiloxane (D4).
1891 Washington, DC: Office of Pollution Prevention and Toxics.
1892 [U.S. EPA.](#) (2025d). Draft Environmental Media and General Population Screening for
1893 Octamethylcyclotetrasiloxane (D4). Washington, DC: Office of Pollution Prevention and Toxics.
1894 [U.S. EPA.](#) (2025e). Draft Environmental Release and Occupational Exposure Assessment for
1895 Octamethylcyclotetrasiloxane (D4). Washington, DC: Office of Pollution Prevention and Toxics.
1896 [U.S. EPA.](#) (2025f). Draft Human Health Hazard Assessment for Octamethylcyclotetrasiloxane (D4).
1897 Washington, DC: Office of Pollution Prevention and Toxics.
1898 [U.S. EPA.](#) (2025g). Draft Physical Chemistry and Fate Assessment for Octamethylcyclotetrasiloxane
1899 (D4). Washington, DC: Office of Pollution Prevention and Toxics.
1900 [U.S. EPA.](#) (2025h). Draft Risk Evaluation for Octamethylcyclotetrasiloxane (D4). Washington, DC:
1901 Office of Pollution Prevention and Toxics.
1902 [U.S. EPA.](#) (2025i). Email from Huntsman on the use of octamethylcyclotetra-siloxane (D4) for the risk
1903 evaluation for D4. Washington, DC.
1904 [UGL.](#) (2023). Safety Data Sheet (SDS): DRYLOK® Siloxane 7. Dunmore, PA.
1905 [https://d2w8l4nyjr77a0.cloudfront.net/resources/Safety-Data-Sheets/DRYLOK_Siloxane_7-](https://d2w8l4nyjr77a0.cloudfront.net/resources/Safety-Data-Sheets/DRYLOK_Siloxane_7-SDS-DRYLOK_Siloxane_7-US-en.pdf)
1906 [SDS-DRYLOK_Siloxane_7-US-en.pdf](https://d2w8l4nyjr77a0.cloudfront.net/resources/Safety-Data-Sheets/DRYLOK_Siloxane_7-SDS-DRYLOK_Siloxane_7-US-en.pdf)
1907 [VT DOH.](#) (2025). Vermont brand name product model data. Waterbury, VT.
1908 [WA DOE.](#) (2015). Chemicals of high concern to children in children's clothing, footwear, and
1909 accessories. (Publication No. 15-03-039). Lacey, WA: Washington Department of Ecology,
1910 Environmental Assessment Program.
1911 [WA DOE.](#) (2017). Formaldehyde, D4, MEK, and styrene in children's products. (Publication No. 17-03-
1912 020). Lacey, WA: Washington Department of Ecology, Environmental Assessment Program.
1913 [White Lightning.](#) (2024). Safety Data Sheet (SDS): WHITE LIGHTNING® SILICONE ULTRA
1914 Window & Door Sealant Clear. Cleveland, OH.
1915 [https://www.paintdocs.com/docs/webPDF.jsp?SITEID=WHITELIGHT&prodno=W31101010&](https://www.paintdocs.com/docs/webPDF.jsp?SITEID=WHITELIGHT&prodno=W31101010&doctype=SDS&lang=2)
1916 [doctype=SDS&lang=2](https://www.paintdocs.com/docs/webPDF.jsp?SITEID=WHITELIGHT&prodno=W31101010&doctype=SDS&lang=2)
1917 [WSDE.](#) (2020). High Priority Chemicals Data System (HPCDS) [Database]. Retrieved from
1918 <https://hpcds.theic2.org/Search>
1919 [WSDE.](#) (2023). PTDB Reporting: Product Testing Database [Database]. Lacey, WA. Retrieved from
1920 <https://apps.ecology.wa.gov/ptdbreporting/Default.aspx>
1921 [Xu, L; Shi, Y; Wang, T; Dong, Z; Su, W; Cai, Y.](#) (2012). Methyl siloxanes in environmental matrices
1922 around a siloxane production facility, and their distribution and elimination in plasma of exposed
1923 population. Environ Sci Technol 46: 11718-11726. <http://dx.doi.org/10.1021/es3023368>
1924 [Yucuis, RA; Stanier, CO; Hornbuckle, KC.](#) (2013). Cyclic siloxanes in air, including identification of
1925 high levels in Chicago and distinct diurnal variation. Chemosphere 92: 905-910.
1926 <http://dx.doi.org/10.1016/j.chemosphere.2013.02.051>
1927

Appendix A ACUTE, CHRONIC, AND INTERMEDIATE DOSE RATE EQUATIONS

A.1 Acute Dose Rate (ADR)

For both products and articles, only gas phase D4 was modeled as partitioning to particulate matter is expected to be limited. For both products and articles, the highest 24-hour average value for exposure concentration in air was used to compute the reported ADR. The ADR therefore represents the maximum time-integrated dose of gas phase D4 over a 24-hour period during the modeled time period (60 days for products, one year for articles).

The acute dose rate (ADR) for inhalation of D4 emitted from products used in an environment was calculated with CEM P_INH1/2 models as follows:

Equation_Apx A-1. Acute Dose Rate for Inhalation of Products Used in an Environment

$$ADR = \frac{C_{air} \times Inh \times ED \times CF_1}{BW \times AT_{acute}}$$

Where:

ADR	=	Acute dose rate (mg/kg-day)
C_{air}	=	Maximum average 24-hour exposure concentration of D4 in air (mg/m ³)
Inh	=	Inhalation rate (m ³ /hr)
ED	=	Exposure duration (days)
BW	=	Body weight (kg)
AT_{acute}	=	Averaging time (days)
CF_1	=	Conversion factor (24 hours/day)

For products, C_{air} is calculated based on the modeled concentration in each zone (zones 1 and 2 as well as near field if selected for product users) and the fraction of each day an age group spends in that zone. The fraction of each day is based on movement patterns in CEM's stay-at-home scenario and designation as a user or bystander. C_{air} is calculated iteratively at a 30-second interval during the first 24 hours and every hour after that for 60 days. It accounts for the chemical emission rate over time, the volume of the house and each zone, the air exchange rate and interzonal airflow rate, and the exposed individual's locations during and after product use. Exposure concentrations are calculated separately for product users and bystanders, then applied to each age group based on designation as a product user. C_{air} is calculated as shown in Equation_Apx A-2 on a rolling 24-hour basis over the entire modeling period and the highest value is used to estimate acute exposure.

Equation_Apx A-2. Acute Exposure Concentration in Air (Products)

$$C_{air} = \max \left(\frac{\sum_t^{t+24} C_{i,t} \times \Delta t}{24 \text{ hours}} \right)$$

Where:

C_{air}	=	Maximum rolling 24-hour average exposure concentration of D4 in air (mg/m ³)
$C_{i,t}$	=	Concentration in Zone i at time t (mg/m ³)
Δt	=	Time interval (hr)

CEM uses two different inhalation rates, one when the person is using the product and another after the use has ended. For bystanders, only the after-use value is applied. Table_Apx A-1 shows the inhalation rates by lifestage during and after product use.

Table_Apx A-1. Inhalation Rates Used in Product and Article Models

Age Group	Inhalation Rate During Use (m ³ /hr) ^a	Inhalation Rate After Use (m ³ /hr) ^b
Adult (≥21 years)	0.74	0.61
Youth (16-20 years)	0.72	0.68
Youth (11-15 years)	0.78	0.63
Child (6-10 years)	0.66	0.5
Small Child (3-5 years)	0.66	0.42
Infant (1-2 years)	0.72	0.35
Infant (<1 year)	0.46	0.23
^a Table 6-2, light intensity values (U.S. EPA, 2011a)		
^b Table 6-1 (U.S. EPA, 2011a)		

The acute dose rate (ADR) for inhalation of D4 emitted from articles placed in environment was calculated as follows:

Equation_Apx A-3. Acute Dose Rate for Inhalation of Emissions from Article Placed in Environment

$$ADR_{Air} = \frac{C_{air} \times InhalAfter \times CF_1 \times ED}{BW \times AT_{acute}}$$

Where:

ADR_{Air}	=	Acute dose rate (mg/kg-day)
C_{air}	=	Maximum average 24-hour exposure concentration of D4 in air (mg/m ³)
$InhalAfter$	=	Inhalation rate (m ³ /hr)
CF_1	=	Conversion factor (24 hrs/day)
ED	=	Exposure duration (days)
AT_{acute}	=	Acute Averaging time (days)
BW	=	Body weight (kg)

For articles, the item was assumed to occur in Zone 1 (room of placement), and Zone 2 was assumed to be the rest of the house as previously described for CEM product models. Total interior volume, room volumes, and air flow rates were also selected to match CEM values for these parameters. C_{air} was calculated based on IECCU outputs for air concentration in Zone 1, Zone 2, and the fraction of each day a resident spends in that zone based on movement patterns in CEM's stay-at-home scenario. This value is the same for all age groups, as there is no user or bystander distinction for articles. For all age groups, only the after-use value for inhalation rates is applied (see Table_Apx A-1). C_{air} was calculated iteratively at 4-hour intervals over the first 72 hours of the modeling period, taking into consideration

the chemical emission rate over time, the volume of the house and each zone, the air exchange rate and interzonal airflow rate, and the exposed individual's time spent in each zone per day. Exposure concentrations are calculated as shown in Equation_Apx A-4 on a rolling 24-hour basis over the first 72 hours of the modeling period, and the highest value is used to estimate acute exposure. Note that because the IECCU diffusion-based emission model takes the form of a single exponential decay model, emissions from the modeled articles and associated air concentrations decline rapidly after the first 24-hour period, so it is not necessary to calculate C_{air} over the entire modeling period to capture the maximum 24-hour average under normal residential ventilation conditions.

Equation_Apx A-4. Acute Exposure Concentration in Air (Articles)

$$C_{air} = \max \left(\frac{\sum_t^{t+24} C_{i,t} \times \Delta t}{24 \text{ hours}} \right)$$

Where:

C_{air}	=	Maximum rolling 24-hour average exposure concentration of D4 in air (mg/m ³)
$C_{i,t}$	=	Concentration in Zone i at time t (mg/m ³), where Zone i is current resident location
Δt	=	Time interval (hr)

For article models, the after-use inhalation rate is used for the duration of exposure modeled.

Acute daily dose rate for ingestion of article mouthed was calculated outside of CEM using the same methods as the CEM A_ING2 model. The equation for acute exposure is as follows:

Equation_Apx A-5. Acute Dose Rate for Ingestion of Article Mouthed

$$ADR = \frac{MR \times CA \times D_m \times ED \times CF_1}{BW \times AT_{acute}}$$

Where:

ADR	=	Acute dose rate (mg/kg-day)
MR	=	Migration rate of chemical from article to saliva (µg/cm ² /mins)
CA	=	Contact area of mouthing (cm ²)
D_m	=	Duration of mouthing (mins/day)
ED	=	Exposure duration (days)
CF_1	=	Conversion factor (1,000 µg/mg)
BW	=	Body weight (kg)
AT_{acute}	=	Acute averaging time (days)

Equation_Apx A-6. Acute applied daily dose rate for dermal exposure to liquids and solids

$$ADR_{Dermal} = \frac{PD_{Dermal} \times FQ_{acute}}{BW \times AT_{acute}}$$

Where:

ADR_{Dermal}	=	Acute applied daily dose rate from dermal contact (mg/kg-day)
PD_{Dermal}	=	Potential dose per dermal contact event (mg/event), see Section 2.4
FQ_{acute}	=	Number of exposure events per day

BW = Body weight (kg)
 AT_{acute} = Acute averaging time (days)

A.2 Non-Cancer Chronic Dose

For both products and articles, only gas phase D4 was modeled as partitioning to particulate matter is expected to be limited. For both products and articles, the average value for exposure concentration in air over the entire modeling period was used to compute reported CADD. This value therefore represents the average time-integrated dose of gas phase D4 over the modeled time period (about one year for both products and articles).

Chronic average daily dose (CADD) for inhalation of D4 emitted from products used in an environment was calculated with CEM P_INH1/2 models as follows:

Equation_Apx A-7. Chronic Average Daily Dose Rate for Inhalation of Product Used in an Environment

$$CADD = \frac{C_{air} \times Inh \times ED \times CF_1}{BW \times AT_{chron}}$$

Where:

$CADD$ = Chronic average daily dose (mg/kg-day)
 C_{air} = Chronic average exposure concentration of D4 in air per use event (mg/m³-event)
 Inh = Inhalation rate (m³/hr)
 ED = Exposure duration (years)
 BW = Body weight (kg)
 AT_{chron} = Averaging time (years)
 CF_1 = Conversion factor (24 hours/day)

For products, C_{air} is calculated based on the modeled concentration in each zone (zones 1 and 2 as well as near field if selected for product users) and the fraction of each day an age group spends in that zone. The fraction of each day is based on movement patterns in CEM's stay-at-home scenario and designation as a user or bystander. C_{air} is calculated iteratively at a 30-second interval during the first 24 hours and every hour after that for 60 days. It accounts for the chemical emission rate over time, the volume of the house and each zone, the air exchange rate and interzonal airflow rate, and the exposed individual's locations during and after product use. A chronic exposure concentration (C_{air}) is then calculated by time-weighting the exposure from individual product use events over a full year. Since emissions are episodic and do not accumulate between events, the contribution of each event is adjusted by the fraction of the year during which exposure occurs. Exposure concentrations are calculated separately for product users and bystanders, then applied to each age group based on designation as a product user. Inhalation rates used to calculate dose were the same as those described in Table_Apx A-1.

Equation_Apx A-8. Chronic Exposure Concentration in Air (Products)

$$C_{air} = \left(\frac{C_{air,event} \times FQ_{chron} \times ED}{CF_1} \right)$$

Where:

September 2025

C_{air}	=	Chronic average exposure concentration of D4 in air (mg/m ³)
$C_{air,event}$	=	Average exposure concentration of D4 in air per use event (mg/m ³ -event)
FQ_{chron}	=	Frequency of products use events (events/year)
ED	=	Duration of elevated air concentrations each modeling period (days)
CF_1	=	Conversion Factor (365 days/year)

$$C_{air,event} = \left(\frac{\sum_{ST}^{ET} C_{i,t} \times \Delta t}{AT_{model} \times CF_1} \right)$$

Where:

$C_{air,event}$	=	Average exposure concentration of D4 in air per use event (mg/m ³ -event)
$C_{i,t}$	=	Concentration in Zone i at time t (mg/m ³)
Δt	=	Time interval (hr)
AT_{model}	=	Averaging time for full modeling period (60 days)
CF_1	=	Conversion Factor (24 hours/day)

CEM uses two different inhalation rates, one when the person is using the product and another after the use has ended. For bystanders, only the after-use value is applied. Table_Apx A-1 shows the inhalation rates by lifestage during and after product use.

Chronic average daily dose rate for inhalation from article placed in environment was calculated as follows:

Equation_Apx A-9. Chronic Average Daily Dose Rate for Inhalation from Article Placed in Environment in Air

$$CADD_{Air} = \frac{C_{air} \times InhalAfter \times CF_1 \times ED}{BW \times AT_{chron}}$$

Where:

$CADD_{air}$	=	Chronic Average Daily Dose (mg/kg-day)
C_{air}	=	Average concentration of D4 in air over the full modeling period (mg/m ³)
$InhalAfter$	=	Inhalation rate (m ³ /hr)
CF_1	=	Conversion factor (24 hrs/day)
ED	=	Chronic exposure duration (365 days)
AT_{chron}	=	Chronic averaging time (365 days)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)

For articles, the item was assumed to occur in Zone 1 (room of placement), and Zone 2 was assumed to be the rest of the house as previously described for CEM product models. Total interior volume, room volumes, and air flow rates were also selected to match CEM values for these parameters. C_{air} was calculated based on IECCU outputs for air concentration in Zone 1, Zone 2, and the fraction of each day a resident spends in that zone based on movement patterns in CEM's stay-at-home scenario. This value is the same for all age groups, as there is no user or bystander distinction for articles. For all age groups, only the after-use value for inhalation rates is applied (see Table_Apx A-1). For all age groups, only the after-use value for inhalation rates is applied (see Table_Apx A-1). C_{air} was calculated iteratively at 4-hour intervals over the entire 10,000 hour (about 1 year) modeling period, taking into consideration the

chemical emission rate over time, the volume of the house and each zone, the air exchange rate and interzonal airflow rate, and the exposed individual's time spent in each zone per day. Chronic exposure concentrations are calculated as shown in Equation_Apx A-10.

Equation_Apx A-10. Chronic Exposure Concentration in Air (Products)

$$C_{air} = \left(\frac{\sum_{ST}^{ET} C_{i,t} \times \Delta t}{10,000 \text{ hours}} \right)$$

Where:

C_{air}	=	Chronic average exposure concentration of D4 in air (mg/m ³)
$C_{i,t}$	=	Concentration in Zone i at time t (mg/m ³)
Δt	=	Time interval (hr)

Chronic average daily dose for ingestion of article mouthed was calculated outside of CEM using the same methods as the CEM A_ING2 model. The equation for acute exposure is as follows:

Equation_Apx A-11. Chronic Average Daily Dose Rate for Ingestion of Article Mouthed

$$CADD = \frac{MR \times CA \times D_m \times ED \times CF_1}{BW \times AT_{chron}}$$

Where:

$CADD$	=	Chronic average daily dose (mg/kg-day)
MR	=	Migration rate of chemical from article to saliva (µg/10 cm ² /mins)
CA	=	Contact area of mouthing (cm ²)
D_m	=	Duration of mouthing (minutes per day)
ED	=	Exposure duration, chronic (365 days)
CF_1	=	Conversion factor (1,000 µg/mg)
AT_{chron}	=	Chronic averaging time (365 days)
BW	=	Body weight (kg)

Equation_Apx A-12. Chronic Average Daily Dose Rate for Dermal Uptake

$$CADD_{Dermal} = \frac{PD_{Dermal} \times FQ_{chron}}{BW \times AT_{chron}}$$

Where:

$CADD_{Dermal}$	=	Chronic applied average daily dose from dermal contact (mg/kg-day)
PD_{Dermal}	=	Potential dose per dermal contact event (mg/event), see Section 2.4
FQ_{chron}	=	Number of exposure events per 365 day averaging period
BW	=	Body weight (kg)
AT_{chron}	=	Averaging time, chronic (365 days)

A.3 Intermediate Average Daily Dose

For all exposure pathways, intermediate doses were calculated for products and articles expected to have episodic exposures that may occur over a short-term but sustained timeframe (about 1 month). Average intermediate daily doses were calculated from the ADR (µg/kg-day) as shown in Equation_Apx A-12. EPA used professional judgment and product use descriptions to estimate events per day and per month for the calculation of the intermediate dose:

Equation_Apx A-13. Intermediate Average Daily Dose Equation

$$IADD = \frac{ADR \times FQ_{int}}{FQ_{acute} \times CF_1}$$

Where:

$IADD$ = Intermediate average daily dose (mg/kg-day)
 FQ_{int} = Intermediate exposure frequency (events per month), see Table_Apx A-2
 FQ_{acute} = Acute exposure frequency (events per day), see Table_Apx A-2
 CF_1 = Conversion Factor (30 days/month)

Table_Apx A-2. Short-Term Event per Month and Day Inputs

Product	Events per Day	Event per Month
Adhesives and sealants	1	3
Paints and lacquers (small projects)	1	4
Paints and lacquers (large projects)	1	4