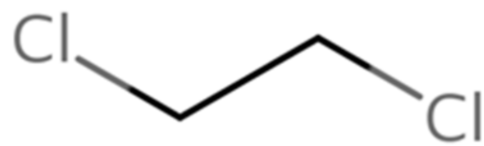
United States
Environmental Protection Agency

EPA Document# EPA-740-R-26-011
April 2026
Office of Chemical Safety and
Pollution Prevention

Consumer Exposure Assessment for 1,2-Dichloroethane

Technical Support Document for the Risk Evaluation

CASRN 107-06-2



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KEY ABBREVIATIONS AND ACRONYMS

ABS	Acrylonitrile butadiene styrene
ADR	Average (or acute) dose rate
CADD	Chronic average daily dose
CASRN	Chemical Abstracts Service Registry Number
CDR	Chemical Data Reporting
CEM	Consumer Exposure Model
CHAD	Consolidated Human Activity Database
CHAP	Chronic Hazard Advisory Panel
COU	Condition of use
EPA	Environmental Protection Agency (U.S.)
HVAC	Heating, ventilation, and air conditioning
IECCU	Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones (Model)
MSS	Modified state-space
OCSPP	Office of Chemical Safety and Pollution Prevention (EPA)
OPPT	Office of Pollution Prevention and Toxics (EPA)
PU	Polyurethane
PVC	Polyvinyl chloride
QPPR	Quantitative property-property relationship
QSPR	Quantitative structure property relationship
RSL	Regional Screening Level
TSCA	Toxic Substances Control Act
TSD	Technical support document
U.S.	United States
VOC	Volatile organic compound

SUMMARY

This technical support document (TSD) accompanies the Toxic Substance Control Act (TSCA) *Risk Evaluation for 1,2-Dichloroethane* (also called the "risk evaluation") (U.S. EPA, 2026c). This assessment describes the use of reasonably available information to evaluate consumer and indoor air exposures to 1,2-dichloroethane from consumer products containing 1,2-dichloroethane (also called the "consumer exposure assessment TSD"). See Appendix C of the risk evaluation (U.S. EPA, 2026c) for a complete list of all TSDs and supplemental files included in the risk evaluation package.

Focus on Consumer Exposure Assessment

During scoping, the U.S. Environmental Protection Agency (EPA or the Agency) considered all conditions of use (COUs) under TSCA, including consumer uses, for 1,2-dichloroethane. A search was performed to identify relevant products and associated scenarios were parameterized. 1,2-Dichloroethane is a colorless, oily liquid with a chloroform-like odor. It is used primarily in the synthesis of vinyl chloride; over 90% of 1,2-dichloroethane is produced to be converted to vinyl chloride (U.S. EPA, 2026c). This TSD provides estimates of the human exposures resulting from consumer uses of 1,2-dichloroethane-containing imported articles. The routes of exposure considered were inhalation, dermal, and ingestion via mouthing.

Approach for Assessing Consumer Exposures

With the limited amount of data associated with the articles containing and emitting 1,2-dichloroethane, EPA conducted high-end exposure analyses for each scenario. In some cases where default parameters were required for exposure estimates, the Agency selected conservative parameters in order to capture the higher exposures across a distribution of possible exposures. This approach was used as a screening analysis to assess risk, and because risk was not identified for any of the consumer scenarios, further refinement of model parameters was not needed.

EPA quantitatively evaluated acute, intermediate, and chronic exposures to consumers associated with 1,2-dichloroethane COUs. Acute exposures are for an exposure duration of 1 day, intermediate exposure durations are 30 days (≈1 month), and chronic exposure durations are 1 year. For inhalation exposure to 1,2-dichloroethane emitted from articles, EPA used either empirically derived air concentration data or the Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones (IECCU) Model to estimate acute and chronic exposures. Exposure via mouthing and dermal contact were estimated based on time of exposure, area of the object exposed, and amount of 1,2-dichloroethane (see Sections 2.5 and 2.6).

Results of Consumer Exposure Assessment

Based on the literature search of 1,2-dichloroethane consumer uses (U.S. EPA, 2026d), EPA identified three types of plastic or rubber articles imported from China that emit 1,2-dichloroethane: molded plastic lamp bases, Christmas ornaments, and squishy toys. In addition, EPA does not have evidence of manufacturing of consumer products containing 1,2-dichloroethane in the United States, supporting the finding that the assessed articles are imported and available domestically. The highest acute inhalation, dermal, and oral (mouthing) exposure estimates are to infants from ornaments. The highest intermediate and chronic inhalation exposures to infants are from emissions from lamp bases, and dermal and oral (mouthing) intermediate exposures are highest from imported Christmas ornaments.

Confidence in the Consumer Exposure Assessment

Confidence in the estimated doses from consumer exposures to 1,2-dichloroethane were moderate or robust depending on the uncertainties associated with input parameters. All parameters used to define

exposure scenarios were determined using reasonably available information and based on professional judgment.

1 INTRODUCTION

1.1 Overview

This consumer exposure assessment TSD evaluates exposures to 1,2-dichloroethane resulting from consumer product use and off-gassing from sources of 1,2-dichloroethane within the indoor environment. It supports the *Risk Evaluation for 1,2-Dichloroethane* (U.S. EPA, 2026c) developed under the Frank R. Lautenberg Chemical Safety for the 21st Century Act, amending TSCA. The risks associated with these exposures are estimated in the *Risk Calculator for Consumer Exposure for 1,2-Dichloroethane* (U.S. EPA, 2026b) and presented in the risk evaluation (U.S. EPA, 2026c). For more information on the reviewed sources used to build this assessment, as well as the evaluation strategies for these sources, refer to the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances Version 1.0; A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called "Draft Systematic Review Protocol") (U.S. EPA, 2021) and *Risk Evaluation Systematic Review Protocol for 1,2-Dichloroethane* (U.S. EPA, 2026d), respectively.

1.2 Exposure Assessment Scope

EPA considered and reviewed reasonably available information through literature, consumer and economic databases, public comments, the Chemical Data Reporting (CDR) rule, and public engagement to inform the scope of this consumer and indoor air exposure assessment for 1,2-dichloroethane. Details of this review are provided below. Overall, this assessment evaluates (1) inhalation exposures to 1,2-dichloroethane for the consumer and indoor air pathways, and (2) dermal and oral exposure for the consumer pathway specifically to consumer products or articles identified that contain and/or emit 1,2-dichloroethane and are a source of exposure to consumers. This TSD evaluates three consumer articles which could result in consumer exposure to 1,2-dichloroethane based on findings in the reasonably available literature. EPA considered acute, intermediate, and chronic non-cancer exposure durations in this consumer and indoor air exposure assessment as described in Section 2.3. As mentioned above, risks associated with these exposures are presented in the *Risk Evaluation for 1,2-Dichloroethane* (U.S. EPA, 2026c).

1.2.1 Chemical Data Reporting (CDR) Database

EPA reviewed the CDR database for the 2020 reporting period and did not find evidence of domestic manufacturing of polymer materials containing 1,2-dichloroethane intended for use in consumer products within the United States. A review of the CDR database for previous reporting years (2012 and 2016) found one facility reported potential downstream consumer use in "Plastic and rubber products not covered elsewhere" (see Table 2-2 of the *Final Scope of the Risk Evaluation for 1,2-Dichloroethane; CASRN 107-06-2* (also called the "final scope document" or "final scope") (U.S. EPA, 2020b)). However, EPA followed up with that facility on this use and the facility clarified the reported downstream use in consumer products of 1,2-dichloroethane was an inadvertent over-classification due to the use of 1,2-dichloroethane in the synthesis of vinyl chloride. This could result in the presence of residual 1,2-dichloroethane in finished polyvinyl chloride (PVC) and post-polymerization PVC. The facility and Vinyl Institute industry trade group further clarified any residual 1,2-dichloroethane would be removed during the steam stripping and drying steps through which all PVC resins pass. Because downstream finishing steps reduce residual 1,2-dichloroethane in consumer products to below detection limits under normal conditions (EPA-HQ-OPPT-2018-0427-0025), exposure to 1,2-dichloroethane from downstream PVC-containing consumer products is expected to be low and was not quantified in this TSD or the risk evaluation.

1.2.2 Published Literature and Other Data Sources

EPA further examined reasonably available information captured by the Agency's systematic review process (including published literature, company websites, and government and commercial trade databases and publications) to further investigate the potential for downstream consumer products and articles available to U.S. consumers belonging to COUs, which may contain measurable concentrations of 1,2-dichloroethane. EPA identified three publications that provided data for emissions of 1,2-dichloroethane from household consumer articles. Two of the publications described items as "molded plastic" but did not provide any other information on specific polymer composition. The third publication provided data on 1,2-dichloroethane emissions from "squishy toys," which are available in U.S. markets. Investigation found that the typical domestic manufacturing processes used to make such consumer articles within the United States do not contain chlorinated compounds in the formulation and thus would not be expected to generate 1,2-dichloroethane under normal conditions. EPA acknowledges that because the above publications provided emissions data of 1,2-dichloroethane, it is possible such manufactured items could be imported to the United States from regions where manufacturing processes result in residual contamination or formation as a byproduct. Therefore, to ensure exposures and associated risks from consumer use of these articles are not missed, EPA aligned these three products to an applicable COU and included these articles in both this consumer exposure assessment and the *Risk Evaluation for 1,2-Dichloroethane* (U.S. EPA, 2026c).

1.2.3 Consumer Conditions of Use Evaluated

Table 1-1 identifies the single consumer COU to which these products were assigned. Although the potential presence in and emissions of 1,2-dichloroethane from these products could extend into disposal, EPA expects residual 1,2-dichloroethane at the time of disposal to be minimal and not result in measurable exposure of concern, as most volatilization from off-gassing occurs within months of consumer use.

Table 1-1. Consumer Conditions of Use of 1,2-Dichloroethane

Life Cycle Stage[a]	Category[b]	Subcategory of Use[c]	References
Consumer	Plastic and rubber products	Plastic and rubber products	(Doucette et al., 2010) (Doucette et al., 2018) (Danish EPA, 2018)

[a] Life cycle stage use definitions (40 CFR 711.3):
- "Consumer use" means the use of a chemical or a mixture containing a chemical (including as part of an article, such as furniture or clothing) when sold to or made available to consumers for their use.

[b] These categories of COUs reflect CDR codes and broadly represent COUs for 1,2-dichloroethane.
[c] These subcategories reflect more specific uses of 1,2-dichloroethane.

2 CONSUMER EXPOSURE APPROACH AND METHODOLOGY

EPA's review of reasonably available information identified three articles that could result in consumer and indoor air exposures to 1,2-dichloroethane under TSCA, as described in Section 1.2. Articles are generally solids, polymers, foams, rubbers, metals, or woods, including children's toys, which are present within indoor environments for the duration of their useful life.

The three types of articles identified to emit 1,2-dichloroethane were imported molded plastic Christmas ornaments, a molded plastic lamp base, and squishy toys. Each of these articles are available to U.S. consumers and are representative of types of articles assumed to be more widely representative of similar imported articles. To EPA's knowledge the molded plastic ornaments comprised only imported Christmas ornaments. The molded plastic lamp base and squishy toys were also imported. The distribution of these three articles across the United States is unknown, and though EPA cannot identify the number of impacted consumers who could be exposed to 1,2-dichloroethane through use of these articles, the Agency did evaluate these as general consumer exposure scenarios.

EPA evaluated consumer and indoor air exposures that are tied to specific consumer conditions of use in accordance with the life cycle diagram and conceptual model presented in both the final scope document (U.S. EPA, 2020b) and the risk evaluation (U.S. EPA, 2026c). As described in Section 1.2, the Agency evaluated inhalation, dermal, and oral exposures for the consumer pathway. Table 2-1 summarizes the consumer COUs, exposure scenarios, and exposure routes for each of the three consumer articles identified above.

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

Consumer Use Category	Consumer Use Subcategory	Article	Exposure Scenario	Routes		
				Inhalation	Dermal	Oral (Mouthing)
Plastic and rubber products	Plastic and rubber products	Molded plastic Christmas ornaments	One or more ornaments are purchased and brought into a home	X	X	X
		Molded plastic lamp base	A new lamp is brought into the home	X		
		Squishy toys	A collection of toys is brought into a home	X	X	X

2.1 Exposure Routes Evaluated

All three articles identified in Table 2-1 were evaluated for exposure via the inhalation route. 1,2-dichloroethane is a volatile organic compound (VOC) expected to readily transition from solid consumer goods to the air based on its physical and chemical properties (U.S. EPA, 2026a). Based on this volatility, 1,2-dichloroethane is expected to remain as a vapor in air and any partitioning to airborne dust or particulate matter is expected to be negligible. Therefore, this consumer and indoor air exposure assessment evaluates 1,2-dichloroethane exposure via the inhalation route as a vapor and does not evaluate exposure to 1,2-dichloroethane via dust ingestion.

Two of the three articles identified in Table 2-1 (plastic Christmas ornaments and squishy toys) were evaluated for exposure via the dermal route. This exposure is assumed to occur through dermal contact with the articles. The plastic Christmas ornaments are shaped like toys (*e.g.,* snowman) and together with the rubber squishy toys were assumed to be treated as such by young children. Exposure through dermal contact typically occurs from direct contact with a solid product. EPA recognizes overall dermal contact with 1,2-dichloroethane through handling these articles may be limited as 1,2-dichloroethane will eventually volatilize from article surfaces rather than remain present in a liquid, oil, or dust on the surface of either article. Nevertheless, because there may be some instances where either article may remain in contact with the skin for some time, EPA considers the dermal route to ensure potential exposures are not missed. In considering the dermal route of exposure via dermal contact, the Agency acknowledges typical dermal contact with Christmas ornaments is likely limited to a limited time during which ornaments are transferred from storage onto a tree or other item. However, it is possible for longer term exposure to occur if ornaments are removed and used as a toy by an infant or young child. Squishy toys are designed to be played with for some time by a consumer; therefore, short and long-term exposures are more likely for such articles. Considering these limitations and assumptions, the consumer exposure assessment includes the dermal route but considers this a bounding exercise capturing the upper bound of a reasonably foreseen exposure scenario.

Two of the three articles identified in Table 2-1 (plastic Christmas ornaments and squishy toys) were evaluated for exposure via the oral route. This exposure is assumed to occur through ingestion of 1,2-dichloroethane due to mouthing of the article. The plastic Christmas ornaments are shaped like toys and both the ornaments and squishy toys are assumed to be treated as toys by young children. Similar to the dermal route, ingestion of 1,2-dichloroethane through mouthing requires 1,2-dichloroethane be present on the surface of the article in some form that can then be ingested during a mouthing event. While the volatility of 1,2-dichloroethane makes this an unlikely scenario, there are some instances where either article may be mouthed (or for the squishy toy article pieces torn off and swallowed during a mouthing event) over time. Therefore, EPA includes in the consumer assessment the oral route but again considers this a bounding exercise capturing upper bound of a reasonably foreseen exposure scenario.

Dermal exposure was not evaluated for molded plastic lamp bases because the short and infrequent dermal contact times with such lamp bases are expected to result in negligible dermal exposures. Oral exposure due to mouthing was not evaluated for molded plastic lamp bases because mouthing is not anticipated for this consumer article.

2.2 Modeling Approaches for Routes Evaluated

EPA assessed acute, intermediate, and chronic non-cancer exposures to 1,2-dichloroethane for the three articles described above in Section 2. The acute dose rate for the consumer exposure assessment was calculated using the maximum time-integrated dose over a 24-hour period during the exposure event. The intermediate dose rate was calculated using the maximum time-integrated dose over a 30-day period. Calculation of the intermediate dose rate relied upon product use descriptions and other information found during prioritization, scoping, and systematic review to estimated events per day and per month. The chronic dose rate was calculated using the maximum time-integrated dose over a 1-year period.

Two approaches were applied when evaluating consumer exposure via the inhalation route depending on the information available—specific physical chemical, fate, and transport properties of 1,2-dichloroethane as well as the type of article. When data for chemical weight fraction or emission rate of 1,2-dichloroethane were available, EPA modeled inhalation exposure using the Agency's peer-reviewed IECCU Model Version 1.1 (U.S. EPA, 2019b). When only chamber concentration data were available, these values were used directly in dose estimates (see Section 3.2). Consumer exposure to 1,2-dichloroethane via the dermal and oral routes were evaluated using a previously peer-reviewed computational spreadsheet format. Sections 2.5 and 2.6 describe this approach as well as key parameters used to evaluate exposures.

2.3 Key Parameters from Literature

Two key parameters (weight fraction or emission rates of 1,2-dichloroethane) utilized to model consumer exposures to 1,2-dichloroethane from the three consumer articles evaluated were only identified in published literature. Other sources considered and reviewed for this consumer and indoor air exposure assessment did not include necessary parameters for modeling or computational spreadsheet format calculations. However, EPA was able to obtain additional information about physical characteristics of 1,2-dichloroethane and potential uses of these articles from technical specifications, manufacturer websites, and vendor websites to inform exposure scenarios. The information identified in the literature is described below.

Christmas Ornaments
Doucette (2010) reported 1,2-dichloroethane measured emission rates from eight molded plastic Christmas ornaments ranging from 0.007 to 0.10 µg/min. The study methods described taking chamber air sample measurements until steady state is reached which Doucette 2018 cited as 120 minutes. Chamber air concentrations provided data to calculate the emission rate as well as change in emissions over time as presented below in Figure 3-1. The Christmas ornament with the highest rate of emission (0.10 µg/min) was used for this consumer and indoor air exposure assessment to provide an upper-bound estimate of 1,2-dichloroethane inhalation exposures to be used for a screening assessment. There were no reported non-detects. Additional information identified for this article (chemical weight fraction and estimated surface area) was used to further characterize the exposure scenario evaluated. The decay rate of 1,2-dichloroethane emissions from this Christmas ornament could not be calculated or modeled based on the single measurement of emission rate. However, the chemical weight fraction reported for this Christmas ornament (2.3 mg 1,2-dichloroethane/g material) was the content of 1,2-dichloroethane within the base material and was used to estimate acute, intermediate, and chronic exposures. 1,2-Dichloroethane was also measured in the study within the coating material (0.4–0.7 mg 1,2-dichloroethane/g) but the authors attributed this amount to diffusing 1,2-dichloroethane from the base material through the surface coatings. EPA, therefore, did not add the amount in coatings to the amount of 1,2-dichloroethane found in the base material.

Plastic Lamp Base
Doucette (2018) reported two emission rates from a molded plastic lamp base measured 9 months apart to inform the decay rate (see Figure 3-1). No data were reported for surface area of this article. The reported emission rates were 4.06 µg/min at the time of the first measurement (May 2013) and 1.46 µg/min at the time of the second measurement (February 2014). The first measurement was used to estimate short-term exposures whereas the second measurement was used to represent intermediate and long-term inhalation consumer exposures to 1,2-dichloroethane via the inhalation route.

Squishy Toys
The Danish EPA reported chamber concentration data for 1,2-dichloroethane emitted from squishy toys (Danish EPA, 2018). 1,2-Dichloroethane was present at measurable concentrations in 5 of the 12 products tested with chamber concentrations ranging from 2 to 8 µg/m^3 after 1-hour Chamber samples were also taken after 3 days though the report does not present these results. Chamber test conditions were chosen such that the measured concentrations in chambers could simulate real world conditions such as ventilation rate. This enabled EPA to use the chamber concentration data directly to evaluate acute, intermediate, and long-term inhalation exposures as described in Section 2.4. Additionally, this information enabled EPA to use the chamber concentration data to evaluate dermal and mouthing exposures as described in Sections 2.5 and 2.6 because the experiments were conducted under

controlled, well-defined conditions.

2.4 Modeling Approach and Key Parameters for Estimating Inhalation Exposure

As described in Section 2.2, two approaches were used to evaluate inhalation exposure from the three articles evaluated (Christmas ornaments, lamp bases, and squishy toys), depending on the information available. For the Christmas ornaments and lamp bases, EPA utilized the IECCU Model Version 1.1 (U.S. EPA, 2019b) to estimate exposures to 1,2-dichloroethane via the inhalation route. For the squishy toys, chamber concentrations measured by the Danish EPA were found in the literature and used directly to estimate exposures to 1,2-dichloroethane via the inhalation route. For all three articles, concentrations were estimated for a 1-year period.

An overview of the IECCU models used in this assessment for inhalation exposure is provided in Section 2.4.1. Key parameters and scenario inputs for each of the three articles evaluated for inhalation exposures are provided in Section 2.4.2. Calculations for inhalation dose are described in Section 2.7.1.

2.4.1 Indoor Environmental Concentrations in Buildings with Conditioned and Unconditioned Zones (IECCU Model)

IECCU is a previously peer-reviewed deterministic model that uses mass balance calculations and considers sources and sinks within the indoor environment to estimate 1,2-dichloroethane concentrations in this consumer and indoor air exposure assessment (U.S. EPA, 2019b). IECCU has over 60 different models available and thus can be used to evaluate a variety of release and exposure scenarios. IECCU has no default input values for any of the models, and therefore all inputs must be user-defined. This allows for the accommodation of distinct input values identified for the three articles containing 1,2-dichloroethane that were evaluated in this exposure assessment. Along these same lines, IECCU requires user defined inputs for environmental parameters (*e.g.,* building and room volumes, air flow, and ventilation rates) which are adjustable over time. IECCU is a higher tier model than EPA's Consumer Exposure Model (CEM) and has flexible equations which are more applicable to VOCs. IECCU can be configured with one, two, or three zones within a building. For this consumer and indoor air exposure assessment, EPA used a two-zone configuration with the modeled article(s) placed in Zone 1.

The choice of emission model within IECCU for 1,2-dichloroethane was guided by the type of data available for each article evaluated. Emissions from the articles evaluated were modeled using either an empirical model (IECCU Model 12) or a diffusion-based model. Both models capture the characteristic pattern of emission from articles (*i.e.,* an initial rapid, high concentration release followed by a prolonged, lower concentration release) but differ in their input requirements. The empirical model requires manual input of an initial emission rate and a first-order decay rate specific to the article modeled. The diffusion-based model relies exclusively on the weight fraction of 1,2-dichloroethane in the article and physicochemical properties of the article controlling emissions. Detailed descriptions of the equations and inputs used for each model in this consumer and indoor air exposure assessment for 1,2-dichloroethane are provided in Sections 2.4.1.1 and 2.4.1.2, respectively.

2.4.1.1 Empirical Emission Rate Model

The Empirical Emission Rate Model requires an initial emission rate and a first order decay rate for the user defined inputs. For 1,2-dichloroethane, both parameters are populated with values obtained from literature. The emission rate at the elapsed time is calculated as shown below in Equation 2-1.

Equation 2-1.

$$R_t = R_0 \, e^{-kt}$$

Where:

R_t	=	Emission rate at time t (h)
R_0	=	Initial emission rate (µg/h)
t	=	Elapsed time (h), and
k	=	Single exponential rate of decay (h^{-1}).

2.4.1.2 Diffusion-Based Emission Rate Model

The diffusion-based emission rate model uses a modified state-space (MSS) method to estimate the emission rate of 1,2-dichloroethane from the articles evaluated. The MSS method divides the solid phase of the article into a finite number of "layers." Using several physicochemical properties, the MSS method then considers the diffusion of 1,2-dichloroethane through each slice until it reaches the top or outermost layer where 1,2-dichloroethane is emitted to air. The rate of emissions from the top slice of the material to air is calculated as shown below in Equation 2-2.

Equation 2-2.

$$R_{ma} = H_A \times A \left(\frac{C_{m1}}{K_{ma}} - C_a \right)$$

Where:

R_{ma}	=	Emission rate from the top (exposed) slice
H_A	=	Overall gas phase mass transfer coefficient (m/h)
A	=	Surface area of the emission source (m^2)
C_{m1}	=	Chemical concentration in the top (exposed) slice (µg/m^3)
K_{ma}	=	Solid:air partition coefficient (dimensionless)
C_a	=	Chemical concentration in air (µg/m^3)

2.4.2 Key Parameters for Estimating Inhalation Exposure

The simulation duration selected for both the empirical and diffusion-based emission rate models, described in Sections 2.4.1.1 and 2.4.1.2, was 10,000 hours, and the number of data points selected was 5,000. EPA used the highest air concentration estimated for a 24-hour period (averaged across 12 consecutive data points) to represent the peak concentrations to evaluate acute exposure to 1,2-dichloroethane. The Agency used the highest air concentrations estimated within a 30-day period (averaged across 720 hours) to evaluate intermediate exposure. EPA also used modeled air concentrations across the entire simulation duration to evaluate long-term chronic non-cancer exposure.

Environment-specific characteristics like room volume and ventilation rates were utilized in both the empirical and diffusion-based emission rate models adjusted for the article and exposure scenario being evaluated. For all articles, the total volume of the home (Zone 1 + Zone 2) was assumed to be 446 m^3 and the indoor-outdoor air exchange rate was assumed to be 0.45 $hour^{-1}$. These values are the recommended values provided in Table 19-1 in EPA's *Exposure Factors Handbook* (also called the "Handbook") (U.S. EPA, 2019a).

For modeling within IECCU, the room in which the article evaluated is located is considered Zone 1 and the rest of the house is considered Zone 2. Typical room dimensions for Zone 1 used for this consumer and indoor air exposure assessment were obtained from EPA's *Exposure Factors Handbook* (U.S. EPA, 2019a). For the Christmas ornament scenario, EPA assumes the articles are in a living room that is 12 feet × 15 feet with 8-feet ceilings. This results in a room volume of 41 m^3 (U.S. EPA, 2019a). For the table lamp and squishy toy scenarios, the items are assumed to be in a bedroom that is 12 feet × 12 feet with 8-feet ceilings. This results in a room volume of 33 m^3.

The interzonal air flows used for the IECCU modeling are a function of the overall air exchange rate and volume of the building as well as the openness of the room. Interzonal air flows are characterized in a regression approach for closed rooms and open rooms. For this consumer and indoor air exposure assessment, EPA uses an interzonal ventilation rate of 109 m^3/h for the living room and 107 m^3/h for the bedroom. These interzonal flow rates are based on a regression approach for closed rooms and open rooms described in (U.S. EPA, 2023).

Article-specific characteristics control the rate of emissions to air and by extension chemical concentrations in air. However, key parameters will differ depending upon the modeling approach selected for each item. A detailed description of modeling strategy and data derivation for each article evaluated is provided below.

Holiday Decorations

The molded plastic Christmas ornaments evaluated in this assessment were modeled in IECCU Version 1.1 with the diffusion-based emission equation described in Section 2.4. The article-specific characteristics used to model emission rates were weight fraction of 1,2-dichloroethane in the material, article surface area (m^2), solid phase diffusion coefficient (m^2/s), surface layer thickness (cm), and the solid-air partitioning coefficient (unitless). The IECCU Model is sensitive to each of these parameters, except the surface layer thickness, and an increase in any one of the remaining parameters considered will result in increased emissions and greater exposure to 1,2-dichloroethane.

The surface area of a single ornament was reported to be 72.6 cm^2 (Doucette et al., 2010). However, similar ornaments were observed for sale from U.S. online retailers in packs of 12. As such, the surface area was adjusted to account for the possibility that multiple ornaments are purchased and enter a home simultaneously. The adjusted surface area value used in this scenario is 870 cm^2. EPA assumed a surface layer thickness of 0.1 cm as recommended in the CEM (U.S. EPA, 2017). The reported weight fraction for this item (2.3 mg 1,2-dichloroethane/g material) was converted to µg/cm^3 by assuming a material density of 1.21 g/cm^3 (material density of standard acrylonitrile butadiene styrene [ABS] polymer); the converted value used in the assessment is 2.78×10^3 µg/cm^3.

Chemical material-specific values for the solid phase diffusion coefficient were estimated with a quantitative property-property relationship (QPPR) developed to predict 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). The QPPR 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. 1,2-Dichloroethane has a molecular weight of 98.95 g/mol, which is well within the domain of applicability for this model. The diffusion coefficient was calculated using the material-specific parameters for poly ABS, which is commonly used to produce molded plastic home goods. The predicted value for solid phase diffusion coefficient is 1.62×10^{-12} m^2/s.

The solid-air partitioning coefficient was estimated with a quantitative structure-property relationship (QSPR) developed to predict partitioning coefficients for many chemicals and materials based on the octanol-air partitioning coefficient, 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. An estimated value for enthalpy of vaporization for 1,2-dichloroethane of 34.8 kJ/mol was obtained from the National Institute of Standards and Technology Chemical Web Book. All other necessary physical and chemical properties are provided in the *Chemistry and Fate and Transport Assessment for 1,2-Dichloroethane* (U.S. EPA, 2026a). The diffusion coefficient was calculated using the material specific parameters for polypropylene, which is commonly used to produce molded plastic home goods. The predicted value for the solid-air partitioning coefficient is 1.53×10^4.

For this consumer and indoor air exposure assessment, EPA assumes the Christmas ornaments evaluated are used seasonally and then stored for the remainder of the 1-year period modeled. Depending upon storage location and conditions, emissions of 1,2-dichloroethane to air may continue to affect indoor air concentrations (Doucette et al., 2010) throughout the year. For this modeled assessment and exposure scenario, EPA assumes the Christmas ornaments are stored within the house in an open/unsealed storage container outside of the holiday season. Therefore, emissions of 1,2-dichloroethane continue to occur and impact indoor air concentrations throughout the year. While storage in an open/unsealed container may be viewed as a high-end scenario due to the emissions continuously occurring for the entire year, considering the rapid decay rates in emissions as the year progresses, it provides a reasonable exposure scenario where 1,2-dichloroethane will continue to volatilize over time. This will decrease the available 1,2-dichloroethane within the Christmas ornament available to volatize year after year. Therefore, the modeled exposure scenario is representative of the 1-year period evaluated for this exposure assessment and provides a health protective estimate for the first year of use (initial opening of new Christmas ornament for use followed by open/unsealed storage). Although storage of the Christmas ornaments could use a sealed container outside of the holiday season, depending on the definition of "sealed" as in how fully sealed a container could be, EPA assumed a worst-case scenario that the container is not fully sealed. However, if a container is fully sealed, 1,2-dichloroethane will continue to be released from the Christmas ornaments during storage although the emissions would remain within the sealed storage container.

Plastic Lamp Base

Plastic lamp bases evaluated for this assessment were modeled in IECCU Version 1.1 with the empirical emission equation described in Section 2.4.1.1. Article-specific characteristics for the plastic lamp bases used for this modeling include 1,2-dichloroethane initial emission rate (µg/h) and first order decay constant (h^{-1}). The emission rate used for this assessment was 4.06 µg/min. This is the initial emission reported by Doucette (2018) and represents the higher of the two emission rates reported and the expected emission rate for a newly opened article. Thus, this emission is a high-end emission rate and health protective value that represents use of a newly opened plastic lamp base. The first-order decay constant used for the plastic lamp base article was calculated as shown in Equation 2-3.

Equation 2-3.

$$k = \frac{\ln\left(R_0/R_1\right)}{t}$$

Where:

R_0	=	Initial emission rate (*i.e.,* the first data point in the paper) (µg/h)
R_1	=	Emission rate at time t (*i.e.,* the second data point in the paper) (µg/h)
t	=	Elapsed time (h), which is 9 months (6,480 h)

The calculated first order decay rate (k) for this article was 1.6×10^{-4} h. This value was used to populate the decay rate parameter in Equation 2-1 described in Section 2.4.1.1.

Squishy Toys
The Danish EPA reported chamber concentration data for 1,2-dichloroethane emitted from squishy toys (Danish EPA, 2018). The data were generated in a 113-liter chamber at typical indoor conditions (23 °C, 50% relative humidity, and 0.5 air exchange per hour). Before the chamber tests, the toys were squeezed 10 times to simulate the realistic use conditions. The concentration data were scaled as described below to a room volume equivalent to a bedroom scenario presented above (12 feet × 12 feet; 8-feet ceilings; total volume of 33 m^3). In addition, the single toy measurement was scaled by a factor of 25 to account for the fact that squishy toys are often purchased as a large set; a value of 40 toys was suggested by the Danish EPA as a high-end estimate, but an informal survey of bagged sets available from U.S. retailers indicated that 25 may be more appropriate. The factors used for this assessment were to scale chamber study conditions of one squishy toy and test chamber volume to a house room volume for 25 toys. The calculation is presented as follows:

- To adjust for room volume in a home (chamber volume/room volume): 0.113 m^3 ÷ 33 m^3 = 0.0034; and
- To adjust for the purchase of a new bag of squishy toys: 0.0034 × 25 = 0.085.

To estimate emission rates for this consumer and indoor air exposure assessment, the maximum reported chamber concentration from the Danish EPA (8 µg/m^3) was modified using the final scaling factor (0.085). This results in an estimated emission rate of 0.68 ug/m^3 (8 µg/m^3 × 0.085 = 0.68 µg/m^3). For this squishy toy scenario, EPA applied a constant emission rate model for this 1,2-dichloroethane consumer and indoor air exposure assessment because a decline in emission rates could not be modeled with reasonably available data considered and reviewed by the Agency. The results presented in Section 3.1 for squishy toys do not capture the typical emission rate decay expected from articles like squishy toys. Although use of a constant emission rate model may provide a high-end exposure scenario for consumers who may only introduce a single or couple squishy toys into the home, it may still represent an average exposure scenario for individuals who may introduce new squishy toys into the home on a routine basis.

2.5 Modeling Approach and Key Parameters for Estimating Dermal Exposure

Dermal exposure to 1,2-dichloroethane from Christmas ornaments and squishy toys were evaluated in this assessment. EPA modeled dermal exposures assuming transfer of emitted 1,2-dichloroethane directly to skin during contact. Key parameters for this exposure modeling approach include the following: surface specific emission rate (µg/cm^2-h), contact time (h), contact surface area (cm^2), and contact frequency (day^{-1}, $year^{-1}$). For this high-end screening assessment, EPA assumed all surface specific emissions of 1,2-dichloroethane to the hands were fully absorbed. This represents an upper-bound exposure scenario and assumes objects are gripped tightly with little room for diffusion to the air.

To estimate contact time for squishy toys, data were obtained from Table 16-26 of EPA's *Children's Exposure Factors Handbook* (U.S. EPA, 2008). Reported values for playtime for children under 15 years of age ranged from 24 to 137 minutes per day, with a mean value of 88 minutes. The maximum value of 137 minutes per day was selected to estimate exposure for both Christmas ornaments and squishy toys. While this may represent an appropriate contact time of children with squishy toys, it represents an upper-bound limit for dermal contact associated with Christmas ornaments (where contact is not expected to occur nearly as frequently every day of the year). Nonetheless, because the Christmas ornaments evaluated for this assessment due to the 1,2-dichloroethane content were all small, colorful plastic items, EPA assumed a child may use these ornaments in a similar manner to action figures or dolls. To ensure possible exposures under this play scenario were not missed, EPA assumed the play time from the *Children's Exposure Factors Handbook* (U.S. EPA, 2008) is representative for Christmas ornaments. Dermal exposure was not modeled for consumers exceeding 15 years of age as the longer-term dermal contact with either Christmas ornaments or squishy toys daily is not expected to be significant.

Contact frequency for Christmas ornaments and squishy toys were assumed to be once per day for each item. Christmas ornaments were assumed to be handled daily for 30 days of the year during the holiday season. Once stored, it is assumed the Christmas ornaments will no longer be available for dermal contact and not likely to be contacted until the following holiday season. Similar to the contact duration described above, the exposure scenario modeled assumes a child plays with Christmas ornaments as if they are a toy. Therefore, while out for use during the holiday season and available for play, the exposure scenario presented assumes 30 days of contact and represents an average exposure estimate. Squishy toys are traditionally intended to be out and available for play daily throughout the year. Therefore, EPA assumes contact frequency for a squishy toy was every day (365 days per year).

Contact surface area was assumed to be the inside of two hands for squishy toys and the inside of one hand for ornaments, which are smaller in size than some larger squishy toys observed for sale.

For the ornament, the surface specific emission rate was calculated as emissions/surface area (µg/h-cm^2). For the squishy toys, surface specific emission rates could not be calculated directly based on the reported data so were estimated using Equation 2-4:

Equation 2-4.

$$R = C \times N \times V$$

Where:

R	=	Emission rate (µg/h)
C	=	Reported 1,2-dichloroethane concentration from chamber tests (µg/m^3)
N	=	Chamber ventilation rate (h^{-1})
V	=	Chamber volume (m^3).

The surface area of the measured squishy toys was not reported. However, the weight for each item was reported and the document stated that they were composed of polyurethane (PU) foam. An estimate for material density was calculated based on item weight and dimensions reported on similar items on retailer websites, yielding a value of 0.91 g/cm^3. There is some uncertainty in this value as the dimensions provided for each item are approximate, but it is well within the range of densities reported by PU foam manufacturers. To estimate the surface area of the squishy toys reported in each chamber test (because EPA is unable to determine surface areas tested based on the data available), a spherical surface area was estimated using the reported sample weight and estimated material density. After generating estimates for both emission rates and surface area, the surface specific emission rate was calculated as emissions/surface area (µg/h-cm^2). Detailed calculations for derivation of all parameters used to estimate dermal exposure can be found in *Risk Calculator for Consumer Exposure for 1,2-Dichloroethane* (U.S. EPA, 2026b).

2.6 Modeling Approach and Key Parameters for Estimating Mouthing Exposure

Oral exposure to 1,2-dichloroethane due to mouthing from Christmas ornaments and squishy toys were evaluated in this assessment. EPA modeled oral exposures assuming transfer of emitted 1,2-dichloroethane directly to the oral cavity during mouthing. Emissions were assumed to fully transfer to saliva and be ingested, in a closed mouth, mouthing scenario. Key parameters for this exposure modeling approach are surface specific emission rate (µg/cm^2-h), mouthing time (h), article area mouthed (cm^2), and mouthing frequency (day^{-1}, $year^{-1}$). Derivation of surface specific emission rates used in this analysis are described in Section 2.5. Both Christmas ornaments and squishy toys were assumed to be mouthed once per day. Consistent with the exposure scenario description and reasoning provided for dermal exposure in Section 2.5, Ornaments were assumed to be mouthed 30 days per year (during play time) and squishy toys assumed to be mouthed 365 days per year (again during playtime). All other parameters are described below.

Mouthing Surface Area

"Mouthing surface area" refers to the specific area of an object that comes into direct contact with the mouth during a mouthing event. A value of 10 cm^2 for mouthing surface area was used in this exposure assessment to evaluate oral exposure of children to 1,2-dichloroethane due to mouthing. This value is a standardized value commonly used in studies to estimate mouthing exposure in children and is based on empirical data reflecting typical mouthing behavior in young children. Therefore, use of this standardized value for this assessment provides a reasonable basis for estimating exposure levels and potential health risks associated with mouthing activities.

Mouthing Duration

Mouthing durations were obtained from Table 4-23 of 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. Values are provided for toys, pacifiers, fingers, and other objects (such towels, clothes, hard surfaces). EPA did not identify article-specific information for mouthing duration for Christmas ornaments and therefore used the mouthing duration values for "other objects" for this exposure assessment. Squishy toys can reasonably be characterized as toys and so the mouthing duration values for "toys" were used for squishy toys. To calculate mouthing durations for each age group in this assessment, all relevant data in Table 4-23 of the Handbook (U.S. EPA, 2011b) were considered together. The maximum value observed across all relevant age groups was used to populate exposure scenarios and is summarized in Table 2-2.

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

	Estimated Mean Daily Mouthing Duration Values from Table 4-23 in *Exposure Factors Handbook* (min/day)				Mouthing Durations for Assessment Age Groups (min/day)		
Item Mouthed	**Reported Age Group**				**Assessment Age Group: Infants (<1 year)**		
	1–3 Months	**3–6 Months**	**6–9 Months**	**9–12 Months**	**Maximum**	**Mean**	**Minimum**
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**				**Assessment Age Group: Infants (1–2 years)**		
	12–15 Months	**15–18 Months**	**18–21 Months**	**21–24 Months**	**Maximum**	**Mean**	**Minimum**
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**				**Assessment Age Group: Small Children (3–5 years)**		
	2 Years	**3 Years**	**4 Years**	**5 Years**	**Maximum**	**Mean**	**Minimum**
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

While the mouthing duration values presented in Table 2-2 for “other objects” used for Christmas ornaments are lower than those for “toys” for the age group less than 1 year of age, the values for “other objects” in the remaining age groups are considerably higher than those for “toys.” This is particularly prevalent in the highest age group (3–5 years old). The reason for this difference is unknown but may be tied to the type of “other objects” the older age groups may mouth including objects associated with eating (*e.g.,* lollipops, plastic eating utensils for children) or other object designed for longer mouthing durations as well as newer “toys” designed for the older age groups, which do not lend themselves as much to mouthing events. These unknown factors in addition to the uncertainty associated with whether a Christmas ornament would be handled and mouthed for the full durations assumed for this assessment further support the estimated oral exposures for Christmas ornaments being an upper-bound limit on potential exposure.

2.7 Dose Calculations

Acute, intermediate and chronic dose rates were calculated for all three consumer articles described in Section 2. An exposure duration of 1 day was used to define acute dose, 30 days was used to define intermediate dose, and 1 year was used to define chronic dose. The calculations utilized to derive inhalation, dermal, and oral doses are presented in Sections 2.7.1 through 2.7.4. Inhalation dose calculations for acute, intermediate, and chronic scenarios are presented in Section 2.7.1. Dermal dose calculations for acute and chronic scenarios are presented in Section 2.7.2. Oral dose (via mouthing) calculations for acute and chronic scenarios are presented in Section 2.7.3. Because the same calculation is used for dermal and oral dose for the intermediate scenario, this calculation is presented in Section 2.7.4. Doses were calculated for the seven distinct age groups defined below:

- (21+ years) → Adults
- (16–20 years) → Teenagers and young adults

- (11–15 years) → Young teens
- (6–10 years) → Middle childhood
- (3–5 years) → Preschoolers
- (1–2 years) → Toddlers
- (<1 year) → Infants

Age group-specific body weights used in calculations were taken from Table 8-1 of the Handbook (U.S. EPA, 2011b). Additional sources of information like inhalation rates are provided in the respective sections.

2.7.1 Inhalation Dose

The inhalation doses presented in this section consider the chemical emission rate over time, the volume of the house and each zone, the air exchange rate, interzonal airflow rate, and the exposed individual's location and inhalation rates. The age-specific inhalation rates utilized in these dose calculations and presented in Table 2-3 are taken from Table 6-1 of EPA's 2011 *Exposure Factors Handbook* (U.S. EPA, 2011a). Air concentrations used to estimate doses come from the derivations presented in Sections 2.4.1.1 and 2.4.1.2.

The acute dose rate for inhalation from an article placed in the indoor environment (room) was calculated per Equation 2-5 below:

Equation 2-5. Acute Dose Rate for Inhalation from an Article Placed in the Indoor Environment in Air

$$ADR_{Air} = \frac{C_{gas\_max} \times FracTime \times InhalRate \times CF_1}{BW \times CF_2}$$

Where:

ADR_{Air}	=	Acute dose rate, air (mg/kg-day)
C_{gas_max}	=	Maximum 24-hour average gas phase concentration (µg/m^3)
$FracTime$	=	Fraction of time in environment (unitless)
$InhalRate$	=	Inhalation rate (m^3/h)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)

The intermediate dose rate for inhalation from an article placed in the indoor environment (room) was calculated per Equation 2-6.

Equation 2-6. Intermediate Average Daily Dose Rate for Inhalation from an Article Placed in the Environment in Air

$$Intermediate\ Daily\ Dose = \frac{C_{month\_avg} \times FracTime \times InhalRate \times CF_1}{BW \times CF_2}$$

Where:

$Intermediate\ Daily\ Dose$	=	Intermediate daily dose rate, air (mg/kg-day)
C_{month_avg}	=	30-day average gas phase concentration (µg/m^3)
$FracTime$	=	Fraction of time in environment (unitless)
$InhalRate$	=	Inhalation rate (m^3/h)
CF_1	=	Conversion factor (24 h/day)

BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)

Chronic average daily dose for inhalation from an article placed in the environment (room) was calculated per Equation 2-7:

Equation 2-7. Chronic Average Daily Dose Rate for Inhalation from an Article Placed in the Environment in Air

$$CADD_{Air} = \frac{C_{year\_avg} \times FracTime \times InhalRate \times CF_1}{BW \times CF_2}$$

Where:

$CADD_{Air}$	=	Chronic dose rate, air (mg/kg-day)
C_{year_avg}	=	Average daily gas phase concentration over 1 year (µg/m^3)
$FracTime$	=	Fraction of time in environment (unitless)
$InhalRate$	=	Inhalation rate (m^3/h)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)

Table 2-3. Inhalation Rates Used in Models

Age Group (years)	Inhalation Rate (m^3/h)
Adults (21+)	0.61
Teenagers (16–20)	0.68
Young Teens (11–15)	0.63
Middle Childhood (6–10)	0.5
Preschoolers (3–5)	0.42
Toddlers (1–2)	0.35
Infants (<1)	0.23

2.7.2 Dermal Dose

The dermal dose estimate assumes that the chemical emitted from the article is absorbed through skin during direct contact with the solid object as described in Section 2.5. For this conservative screening analysis, all 1,2-dichloroethane emitted from the article was assumed to be absorbed for this exposure scenario. This represents an upper-bound exposure scenario and assumes objects are gripped tightly with little room for diffusion to the air.

Acute daily dose rate for dermal adsorption was calculated per Equation 2-8:

Equation 2-8. Acute Dose Rate for Dermal Dose

$$ADR = \frac{MR \times CA \times D_m \times ED_{ac} \times CF_1}{BW \times AT_{ac} \times CF_2 \times CF_3}$$

Where:

ADR	=	Acute dose rate (mg/kg-day)
MR	=	Surface specific emission rate (µg/cm^2-h)
CA	=	Contact area (cm^2)
D_m	=	Duration of contact (min/h)
ED_{ac}	=	Exposure duration, acute (days)
CF_1	=	Conversion factor (24 h/day)
BW	=	Body weight (kg)
AT_{ac}	=	Averaging time, acute (days)
CF_2	=	Conversion factor (1,000 µg/mg)
CF_3	=	Conversion factor (60 min/h)

Chronic average daily dose rate for dermal absorption was calculated per Equation 2-9:

Equation 2-9. Chronic Average Daily Dose Rate for Ingestion of Article Mouthed

$$CADD = \frac{MR \times CA \times D_m \times \ ED_{cr} \times CF_1}{BW \times AT_{cr} \times CF_2 \times CF_3}$$

Where:

$CADD$	=	Chronic average daily dose (mg/kg-day)
MR	=	Surface specific emission rate (µg/cm^2-h)
CA	=	Contact area (cm^2)
D_m	=	Duration of contact (min/h)
ED_{cr}	=	Exposure duration, chronic (years)
CF_1	=	Conversion factor (24 h/day)
AT_{cr}	=	Averaging time, chronic (years)
BW	=	Body weight (kg)
CF_2	=	Conversion factor (1,000 µg/mg)
CF_3	=	Conversion factor (60 min/h)

2.7.3 Oral Dose

The oral dose estimate due to mouthing assumes that the chemical emitted from the article is ingested via object-to-mouth contact as described in Section 2.6. For this conservative screening-level analysis, all 1,2-dichloroethane emitted from the article is assumed to migrate from the article to the saliva and subsequently ingested in a closed mouth scenario. Therefore, this exposure scenario represents an upper-bound, oral exposure estimate.

Acute daily dose rate for ingestion of article mouthed was calculated per Equation 2-10:

Equation 2-10. Acute Dose Rate for Ingestion of Article Mouthed

$$ADR = \frac{MR \times CA \times D_m \times \ ED_{ac} \times CF_1}{BW \times AT_{ac} \times CF_2 \times CF_3}$$

Where:

ADR	=	Acute dose rate (mg/kg-day)
MR	=	Surface specific emission rate (µg/cm^2-h)
CA	=	Contact area of mouthing (cm^2)
D_m	=	Duration of mouthing (min/h)

ED_{ac} = Exposure duration, acute (days)
CF_1 = Conversion factor (24 h/day)
BW = Body weight (kg)
AT_{ac} = Averaging time, acute (days)
CF_2 = Conversion factor (1,000 µg/mg)
CF_3 = Conversion factor (60 min/h)

Chronic average daily dose rate for ingestion of article mouthed was calculated per Equation 2-11:

Equation 2-11. Chronic Average Daily Dose Rate for Ingestion of Article Mouthed

$$CADD = \frac{MR \times CA \times D_m \times ED_{cr} \times CF_1}{BW \times AT_{cr} \times CF_2 \times CF_3}$$

Where:

$CADD$ = Chronic average daily dose (mg/kg-day)
MR = Surface specific emission rate (µg /cm^2-h)
CA = Contact area of mouthing (cm^2)
D_m = Duration of mouthing (min/h)
ED_{cr} = Exposure duration, chronic (years)
CF_1 = Conversion factor (24 h/day)
AT_{cr} = Averaging time, chronic (years)
BW = Body weight (kg)
CF_2 = Conversion factor (1,000 µg/mg)
CF_3 = Conversion factor (60 min/h)

2.7.4 Mouthing and Dermal Intermediate Average Daily Dose

For dermal and oral exposures, the intermediate doses were calculated from the average daily dose, ADD, (µg/kg-day) for each route presented above. EPA then assumes daily exposure for 30 days as described in Sections 2.5 and 2.6 to calculate the intermediate dose per Equation 2-12:

Equation 2-12. Intermediate Average Daily Dose Equation

$$Intermediate\ Dose = \frac{ADD \times Event\ per\ Month}{Events\ per\ Day}$$

Where:

$Intermediate\ Dose$ = Intermediate average daily dose, µg/kg-month
ADD = Average daily dose, µg/kg-day
$Event\ per\ Month$ = Events per month, month^{-1}
$Event\ per\ Day$ = Events per day, day^{-1}

3 MODELING RESULTS

This section summarizes the modeled concentrations of 1,2-dichloroethane in indoor air and dose estimates from inhalation, dermal, and oral exposure from consumer articles. Exposure via the inhalation route occurs from inhalation of 1,2-dichloroethane gas-phase emissions and was evaluated for all three articles identified in Section 2.1. Exposure via the dermal route occurs from direct contact with articles containing 1,2-dichloroethane that migrates through the article's solid matrix to the surface where dermal contact occurs as described in Section 2.5. Dermal exposure was evaluated for two consumer articles (Christmas ornaments and squishy toys). Exposure via the oral route (via mouthing) was evaluated for children aged 5 years or less under from direct mouthing of articles containing 1,2-dichloroethane that migrates through the article's solid matrix to the surface where 1,2-dichloroethane fully migrates from the article to saliva and is ingested as described in Section 2.6. Oral exposure was evaluated for two consumer articles: Christmas ornaments and squishy toys.

3.1 Modeled Concentrations of 1,2-Dichloroethane in Air

Modeled 24-hour average, 30-day average, and 1-year average indoor air concentrations for each consumer article modeled for consumer exposure are presented below in Table 3-1.

Table 3-1. Modeled Average Air Concentrations (µg/m^3) for Acute (24-Hour), Intermediate (30-Day), and Chronic (1-Year) Durations

Representative Article	24-Hour Average Concentration (µg/m^3)	30-Day Average Concentration (µg/m^3)	1-Year Average Concentration (µg/m^3)
Ornaments[a]	3.18	0.63	0.17
Lamp base[b]	1.67	1.58	0.84
Squishy toys[c]	0.28	0.28	0.28

[a] Based on IECCU diffusion emission rate model, consistent with decay rate in Figure 3-1.
[b] Based on IECCU empirical emission rate model, represented by linear decay as presented Figure 3-1.
[c] Direct measured concentrations from a chamber study for squishy toys used to determine average concentrations across exposure durations.

Emissions of VOCs from newly purchased polymer materials generally exhibit an initial period of high emissions followed by a rapid decline in emission rate that is often described by a first or second order decay coefficient (Even et al., 2019). This behavior is consistent with the presented findings for 1,2-dichloroethane as shown in Figure 3-1 for one article (Christmas ornaments) that used the diffusion-based emission rate model within IECCU as discussed in Section 2.4.1.2.

The modeled timeframe for 1,2-dichloroethane inhalation exposure went out to a single year, therefore the averages presented above are high-end estimates for exposures. Considering the decay rate seen in Figure 3-1 for Christmas ornaments, if a longer time frame was modeled, the average exposure concentration would be lower. Therefore, the exposure scenario modeled and presented for Christmas ornaments represents a high-end, health protective scenario compared to longer modeled time frames.

EPA did not identify the necessary data to allow use of the diffusion-based emissions rate model with IECCU for the remaining two articles (lamp base and squishy toys). The Agency used an empirical emission rate model in IECCU for the lamp base to determine average concentrations presented in Table 3-1. EPA used direct measured concentrations from a chamber study for squishy toys to determine average concentrations presented in Table 3-1. Although a decrease in concentrations for the lamp base can be seen in Table 3-1 and Figure 3-1, the change in concentrations is linear rather than following the first/second-order decay rates as characterized by Christmas ornaments. Use of the measured concentrations directly to determine concentrations of 1,2-dichloroethane in the ambient air from squishy toys results in a constant emission rate for each time duration considered in this assessment.

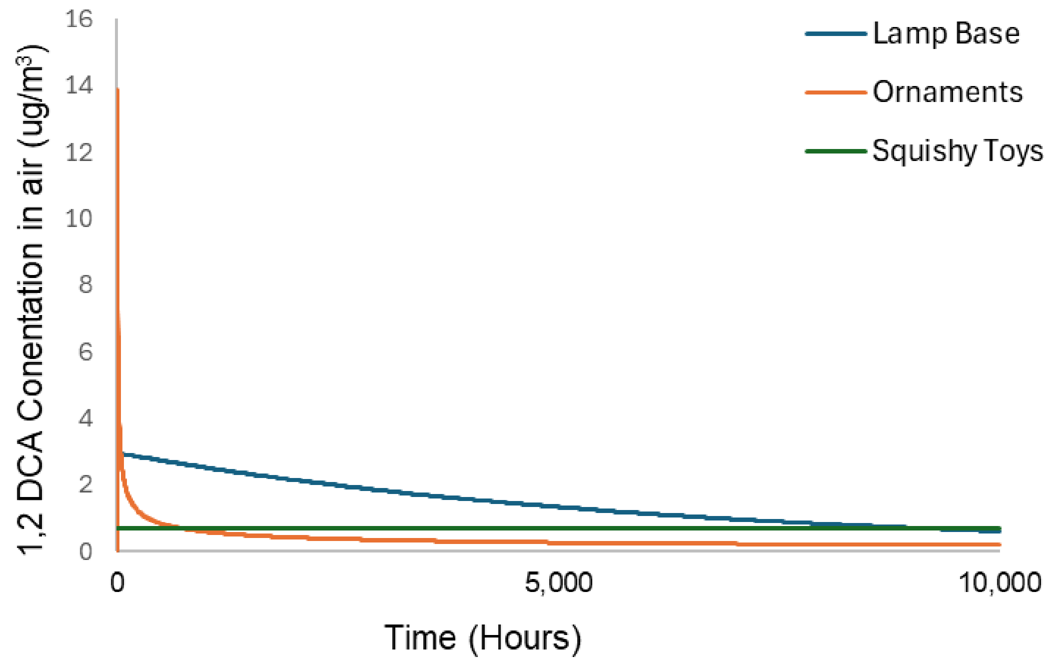

Figure 3-1. Modeled Concentrations of 1,2-Dichloroethane in Zone 1 Air over a 10,000-Hour (≈1-Year) Period Resulting from Emissions from Each Representative Article

3.2 Ingestion, Inhalation, and Dermal Uptake Doses

Acute, intermediate, and chronic doses for inhalation, dermal, and oral routes for all age groups and all three consumer articles evaluated are presented in Figure 3-2, Figure 3-3, and Figure 3-4. The associated dose data for each route, age group, and consumer article evaluated are also compiled in Table 3-2.

In general, 1,2-dichloroethane doses were highest in the younger age groups (infants and toddlers) and lowest for adults. This is expected due to compounding physical and behavioral differences between the age groups. Specifically, infants and toddlers are more likely to handle, play, and mouth these items for a longer duration than adults. For example, the handling of Christmas ornaments by adults (dermal exposure) are more likely to be short durations to place on the item decorated (a tree for instance), while infants and toddlers may take from the decorated item to handle, play, and mouth them for an extended time, which is a conservative assumption. For oral exposures, mouthing of Christmas ornaments is not an activity an adult would participate in; therefore, as discussed in Section 2.5, was not assessed for individuals over 15 years of age. However, as discussed in Sections 2.4, 2.5, and 2.6, all age groups are assumed to be exposed via inhalation and dermal exposures to the same concentrations in 1,2-dichloroethane for the duration of the exposure period. Thus, other physical factors, such as the surface area of the skin relative to different age groups, lower body weight for younger age groups, and higher relative inhalation rates in younger age groups, can all contribute to the differences in doses shown in Figure 3-2, Figure 3-3, and Figure 3-4 and compiled in Table 3-2.

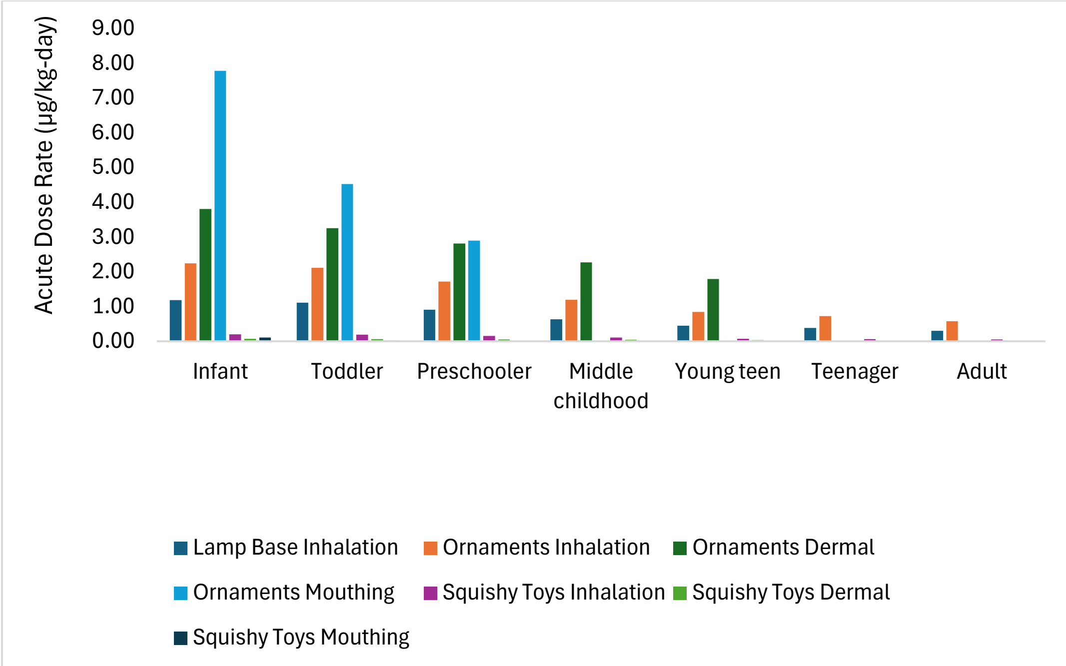

Figure 3-2. Acute Dose Rate (µg/kg-day) for All Age Groups and All Exposure Paths

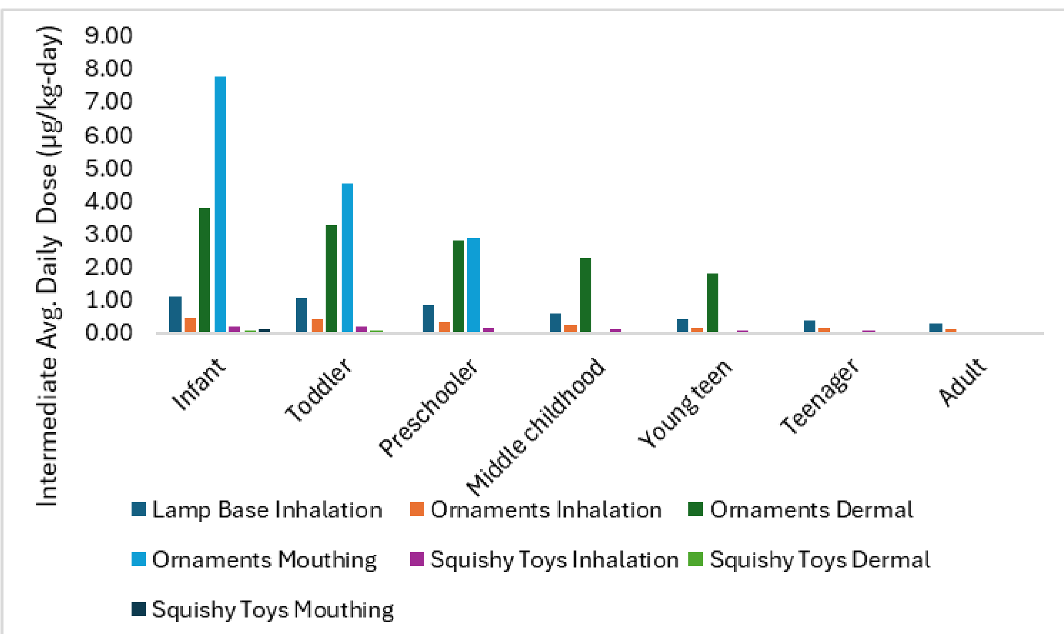

Figure 3-3. Intermediate Average Daily Dose (µg/kg-day) for All Age Groups and Exposure Paths

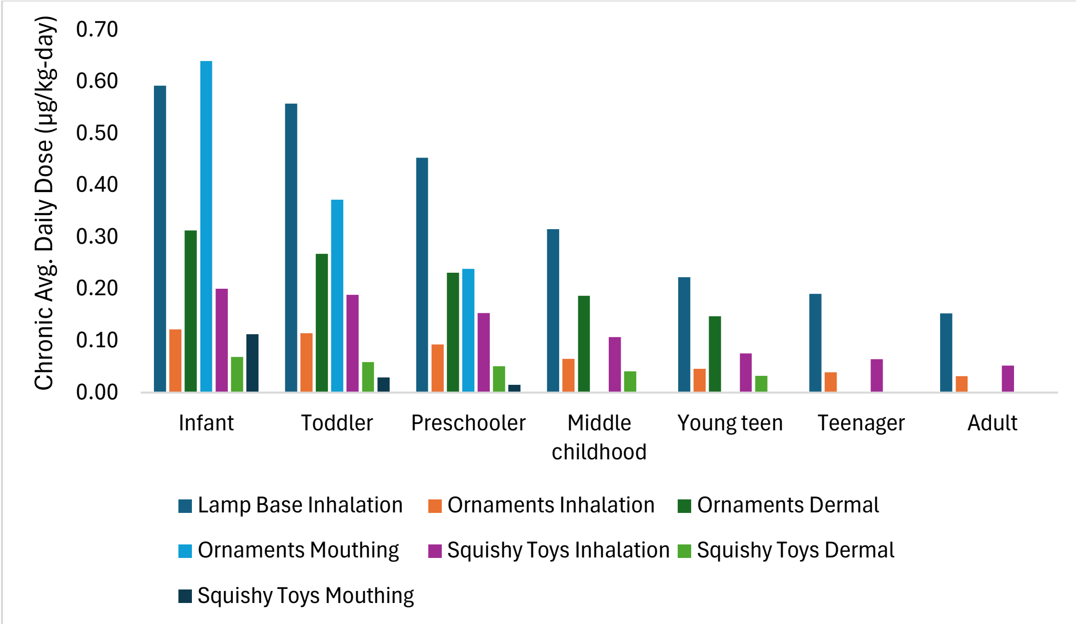

Figure 3-4. Chronic Average Daily Dose (µg/kg-day) for All Age Groups and Exposure Paths

Table 3-2. Inhalation, Ingestion, and Dermal Doses of 1,2-Dichloroethane (µg/kg-day) for Acute, Intermediate, and Chronic Exposure Windows

Representative Article	Exposure Route	Infants	Toddlers	Preschoolers	Middle Childhood	Young Teens	Teenagers	Adults
Acute dose rate (ADR) (µg/kg-day)								
Lamp base	Inhalation	1.18	1.11	0.90	0.63	0.44	0.38	0.31
Ornaments	Inhalation	2.25	2.12	1.72	1.20	0.85	0.72	0.58
Ornaments	Dermal	3.81	3.26	2.82	2.27	1.79	–	–
Ornaments	Mouthing	7.79	4.53	2.90	–	–	–	–
Squishy toys	Inhalation	0.20	0.19	0.15	0.11	0.08	0.06	0.05
Squishy toys	Dermal	0.07	0.06	0.05	0.04	0.03	–	–
Squishy toys	Mouthing	0.11	0.03	0.01	–	–	–	–
Intermediate average daily dose (µg/kg-day)								
Lamp base	Inhalation	1.12	1.05	0.86	0.60	0.42	0.36	0.29
Ornaments	Inhalation	0.45	0.42	0.34	0.24	0.17	0.14	0.12
Ornaments	Dermal	3.81	3.26	2.82	2.27	1.79	–	–
Ornaments	Mouthing	7.79	4.53	2.90	–	–	–	–
Squishy toys	Inhalation	0.20	0.19	0.15	0.11	0.08	0.06	0.05
Squishy toys	Dermal	0.07	0.06	0.05	0.04	0.03	–	–
Squishy toys	Mouthing	0.11	0.03	0.01	–	–	–	–
Chronic average daily dose (CADD) (µg/kg-day)								
Lamp base	Inhalation	0.59	0.56	0.45	0.32	0.22	0.19	0.15
Ornaments	Inhalation	0.12	0.11	0.09	0.06	0.05	0.04	0.03
Ornaments	Dermal	0.31	0.27	0.23	0.19	0.15	–	–
Ornaments	Mouthing	0.64	0.37	0.24	–	–	–	–

Representative Article	Exposure Route	Infants	Toddlers	Preschoolers	Middle Childhood	Young Teens	Teenagers	Adults
Squishy toys	Inhalation	0.20	0.19	0.15	0.11	0.08	0.06	0.05
Squishy toys	Dermal	0.07	0.06	0.05	0.04	0.03	–	–
Squishy toys	Mouthing	0.11	0.03	0.01	–	–	–	–

The results presented in Figure 3-2, Figure 3-3, and Figure 3-4 and compiled in Table 3-2 show the highest acute and intermediate dose rates occur from oral exposure (via mouthing) of Christmas ornaments in both infants and toddlers. Acute and intermediate dose rates for the preschool age group is about equal for both dermal and oral exposure of Christmas ornaments within this age group, but lower than associated exposures in the infant and toddler age group. The highest chronic dose rates for these three age groups show a similar trend for dermal and oral routes. The acute and intermediate dose rates for Christmas ornaments via the oral and dermal routes in all three of these age groups are much higher than the associated acute and intermediate dose rates for the articles via the inhalation route. Considering the assumptions made for the Christmas ornaments dermal and oral exposure scenarios discussed in Sections 2.5 and 2.6, these results support the description of these scenarios as an upper-bound exposure estimate for 1,2-dichloroethane.

The highest acute dose rates for the inhalation route occur for Christmas ornaments across all age groups followed by dose rates from the molded plastic lamp base. In contrast, the highest intermediate dose rates for the inhalation route occur from the molded plastic lamp base followed by Christmas ornaments. For both acute and intermediate dose rates for the inhalation route squishy toys contributions to 1,2-dichloroethane exposures are minimal. The highest chronic dose rates for the inhalation route are dominated by the molded plastic lamp base, followed by squishy toys, though chronic dose rates from Christmas ornaments are only slightly below squishy toys. Long-term exposures to 1,2-dichloroethane via the inhalation route from the molded plastic lamp base is expected since a lamp is typically opened and then left out continuously where constant releases of 1,2-dichloroethane can occur leading to inhalation exposures. Squishy toy contributions to chronic dose rates relative to Christmas ornaments via the inhalation route may be due to more frequent use of squishy toys by the age groups evaluated. This is particularly true if the action of squishing a squishy toy drives the release of 1,2-dichloroethane from the article during use. The lower chronic dose rates from ornaments may be due to the scenario evaluated where direct releases of 1,2-dichloroethane to the air would primarily occur when the Christmas ornaments are in use and out in the open during the holiday season. Outside of the holiday season, ornaments were assumed to be stored (even though stored in an open/unsealed container for the scenario evaluated in this assessment), which would be expected to result in a lower exposure from the stored/unused Christmas ornament for the majority of the year, relative to a squishy toy that may remain in the open and be used more frequently throughout the year.

4 1,2-DICHLOROETHANE MEASUREMENTS IN INDOOR AIR

Measured concentrations of 1,2-dichloroethane in indoor air (µg/m^3) were identified and extracted from four sources and are presented in Figure 4-1 and in Table 4-1. Overall, concentrations ranged from not detected to 140 µg/m^3 from 440 samples collected between 1987 and 2010. Location types were categorized as residential and the reported detection frequency ranged from 0 to 100%.

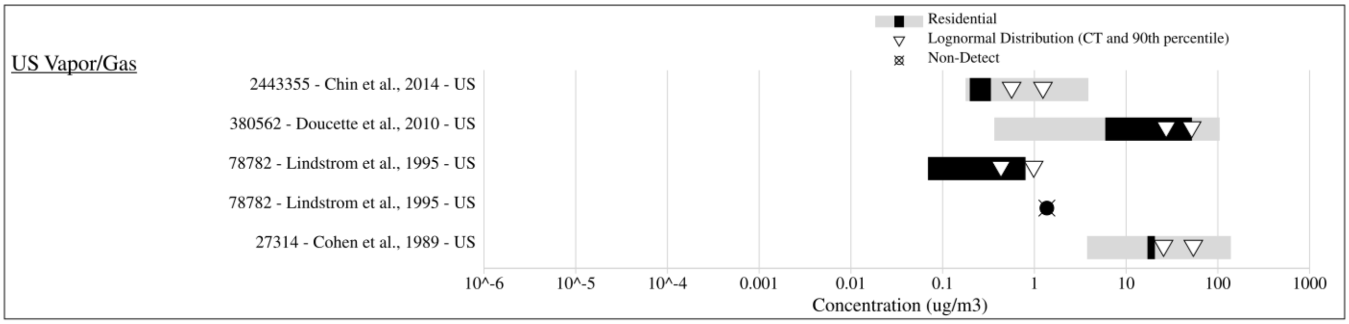

Figure 4-1. Concentrations of 1,2-Dichloroethane (µg/m^3) in Vapor/Gas Fraction of Indoor Air from 1987–2017

Table 4-1. Summary of Peer-Reviewed Literature that Measured 1,2-Dichloroethane (µg/m^3) Levels in the Vapor/Gas Fraction of Indoor Air in the United States

Citation	Location Type	Potential Source of 1,2-Dichloroethane Cited in Study	Sampling Year(s)	Sample Size (Frequency of Detection, %)	Detection Limit (µg/m^3)	Overall Quality Level
Chin et al. (2014)	Residential	Household products	2009–2010	325 (13)	0.39	High
Doucette et al. (2010)	Residential	Consumer products/objects	2008	12 (100)	N/R	Medium
Doucette et al. (2010)	Residential	Suspected Vapor intrusion	2008	530 (18)	N/R	Medium
Lindstrom et al. (1995)	Residential	Residential items after occupancy; Conventional building materials	1992–1993	34 (6)	1.62	Medium
Lindstrom et al. (1995)	Residential	Pre-occupancy; Low-emitting and conventional building materials	1992–1993	34 (0)	2.77	Medium
Cohen et al. (1989)	Residential	Household products	1987	35 (63)	7.6	Medium

N/R = not reported; US = United States
Study quality metrics are described in detail in the Draft Systematic Review Protocol (U.S. EPA, 2021) and the *Systematic Review Protocol for 1,2-Dichloroethane* (U.S. EPA, 2026d).

Among the studies from the United States five involved concentrations within residents that may be associated with COUs and relevant to indoor and consumer exposures. These six studies are discussed in detail below.

Lindstrom (1995) evaluated indoor air quality in six experimental homes designed using low-emitting building materials and methods to improve indoor air quality, and three conventionally built homes in a suburban area of Denver, Colorado. Each home was sampled soon after construction and prior to occupancy, in December 1992, and 5 to 6 months after occupancy, in May 1993. None of the nine pre-occupancy measurements detected 1,2-dichloroethane in indoor air and only one of the three conventionally built home after occupancy measured 1,2-dichloroethane in indoor air with a reported geometric mean of 0.19 $\mu g/m^3$. These results could suggest that 1,2-dichloroethane is not commonly used in either low-emitting or conventional building materials.

Doucette (2010) measured 1,2-dichloroethane in indoor air in residences in Utah near groundwater contamination associated with an industrial facility. Indoor air sampling was performed starting in 2003 to assess possible vapor intrusion in residences overlying the contaminated groundwater. Indoor air quality was monitored at approximately 530 residences (450 of which were located above the plume) and included approximately 1,900 samples collected over a 24-hour period. 1,2-Dichloroethane was detected in 96 of the residences at concentrations ranging from 0.06 to 130 $\mu g/m^3$ but it is uncertain as to which of the 530 residence and when these samples were taken. However, some measurements of 1,2-dichloroethane occurred in homes that did not overline the contaminated groundwater, which suggests internal sources were likely the source of 1,2-dichloroethane observed in the air samples rather than vapor intrusion.

A room-by-room sampling approach was performed using Tenax sorbent tube sampling in five residences where 1,2-dichloroethane was previously detected. Samples were collected for approximately 10 to 30 minutes at known flow rates from 100 to 150 mL/min. This initial sampling led to more detailed investigations at two residences.

In one of the residences (overlying contaminated groundwater), the highest concentration (82 $\mu g/m^3$) was in a basement room used for storage. This was significantly higher than concentrations in other rooms that were between 0.41 to 12 $\mu g/m^3$. Repeated sampling of the basement and attached garage with and without the items suggested that the items in the storage room contain source(s) of 1,2-dichloroethane. Specifically, the source(s) were in plastic storage containers with holiday decorations. Air samples from three decoration storage containers were sampled at random and concentrations of 14, 65, and 290 $\mu g/m^3$ were measured. The 1,2-dichloroethane measurements from objects in the container with the highest concentration were quantified using a flow-through chamber system. The main source was identified to be a small painted Christmas ornament (surface area of ≈72.6 cm^2) that emitted 0.3 µg/min of 1,2-dichloroethane with a 95% confidence internal of 0.025 µg/min. Samples of the surface coatings and base materials (base materials were defined in the study as the material below the coating) were extracted and analyzed. The item weighed 64.8 g and the reported average concentration in the base material was 2.3 mg 1,2-dichloroethane/g, which was about five times higher than the concentrations in the surface coatings that ranged from 0.4 to 0.7 mg 1,2-dichloroethane/g.

Doucette (2010) reported uncertainties in source attribution between the base material and the surface coatings of the ornament because the 1,2-dichloroethane found in the coating could be from small pieces of base material mixed in or from diffusion from the base material to the coatings. Seven visually similar molded plastic ornaments purchased from retail stores were also analyzed for 1,2-dichloroethane for comparison. The weights of these holiday ornaments ranged from 42.9 to 118.8 g and the 1,2-dichloroethane emission rates ranged from 0.007 to 0.10 µg/min. The study did not provide an emission rate per gram of ornament but EPA calculated this value that ranged from 2.5×10^{-3} µg/min/g for the gingerbread ornament to 1.0×10^{-4} µg/min/g for a "nest Santa." The 1,2-dichloroethane emissions from similar newly purchased ornaments suggested that the 1,2-dichloroethane emissions measured from the ornament in the residence were not associated with vapor intrusion. Additionally, a predicted indoor air concentration of 0.13 μg/m^3 was calculated based on the emission rate of 0.3 μg/min measured from the ornament found in the residence. Because the study authors reported this emission rate for one item and reported that many similar items were present in the residence, the calculated concentrations for emission rates from multiple similar items would be higher. Following this study, eight homes where 1,2-dichloroethane was detected were further investigated and molded plastic decorations emitting 1,2-dichloroethane were found to be present at all of the homes.

Doucette (2018) performed emission chamber measurements and residence emission studies on consumer products to determine if emissions from consumer products were impacting indoor air concentrations measured during previously conducted vapor intrusion investigations. 1,2-Dichloroethane was identified in an injection molded plastic lamp base. To measure indoor air concentrations of 1,2-Dichloroethane resulting from the molded plastic lamp base, three studies were conducted over a 13-month period by placing the lamp base in a room on the second floor and collecting air samples in the source room, the main floor room, and the basement room before and after turning on the HVAC (heating, ventilation, and air conditioning) system. Samples were collected for about 10 to 30 minutes at known flow rates of approximately 100 mL/min. The average measured indoor air concentration of 1,2-dichloroethane across all rooms when the HVAC system was on was 3.55 μg/m^3. Indoor air concentrations were relatively constant across all sampling areas when the HVAC was on because of efficient air mixing. The measured concentrations were then compared to predicted indoor air concentrations based on a laboratory-measured emission rate. Indoor air concentrations were estimated from a laboratory measured product emission rate (4.06 ± 0.15 μg/min), an average air exchange rate measured, and the indoor air volume calculated from the measured room dimensions (600 m^3). The estimated 1,2-dichloroethane concentration based on the laboratory-measured emission rate was 2.2 μg/m^3, which is similar to the actual measured indoor air concentration of 3.55 μg/m^3, indicating that indoor sources of 1,2-dichloroethane concentration have an impact on indoor air concentrations and confound vapor intrusion investigations. Additionally, the study provided a comparison of the measured 1,2-dichloroethane from their house study against EPA's target cancer risk and hazard quotient screening levels for 1,2-dichloroethane from EPA's Regional Screening Level (RSL) for Resident Ambient Air (accessed April 13, 2026), which are risk-based screening levels used by the EPA for screening chemicals at Superfund sites. The RSLs are screening level and are provided as comparison values for residential and commercial/industrial exposures. The comparison showed, the consumer product emissions can be similar to or even exceed these levels.

Chin (2014) also found potential links between 1,2-dichloroethane concentrations in homes and consumer products but did not confirm 1,2-dichloroethane content in specific products identified. This study characterized VOCs in 126 homes of children with asthma in Detroit, Michigan, from March 2009 to September 2010. Bedrooms and main living areas were sampled using tube-type passive samplers over a 7-day period. 1,2-Dichloroethane was detected in 13% of samples and the reported mean and standard deviation were 0.34 ± 0.51 μg/m^3. The detected concentrations ranged from 0.18 to 3.93 μg/m^3. Factor analyses indicated degreasers, paint remover, and moth crystals as potential sources of 1,2-dichloroethane. However, that study did not measure the concentrations in these products and the authors reported that the factor analysis only provides a tentative identification of sources.

In summary, in most studies, 1,2-dichloroethane concentrations in indoor air were detectable in less than half of sampled residences and measured concentrations of 1,2-dichloroethane in indoor residential air were generally low. Two studies provided evidence that 1,2-dichloroethane can be emitted from molded plastic articles (Doucette et al., 2018; Doucette et al., 2010). Chin (2014) found some association between liquid products including degreasers and paint thinners. No products of this type were identified with 1,2-dichloroethane content during this risk evaluation, and it remains unclear whether it was at any point included in formulations.

5 WEIGHT OF SCIENTIFIC EVIDENCE

5.1 Consumer Exposure Analysis Weight of Scientific Evidence

The migration of 1,2-dichloroethane from plastic and rubber consumer articles has been identified as a potential source of exposure; however, the relative contribution of various consumer goods to overall exposure to 1,2-dichloroethane has not been well characterized. Given the limited data available and uncertainties regarding the percent concentration of 1,2-dichloroethane that might be present in consumer articles, EPA evaluated exposures to 1,2-dichloroethane via the inhalation, dermal, and oral routes. The Agency's approach to this evaluation applied health-protective assumptions for exposure model inputs and high-end/upper-bound estimates to characterize exposures. This included assuming 100% absorption for all relevant exposure pathways (inhalation, dermal contact, and oral [via mouthing and ingestion])—even though bioavailability is likely lower. Behavioral parameters were also selected to reflect high-end estimates across the age groups evaluated. For example, maximum values for total daily durations of playtime and mouthing from the *Exposure Factors Handbook* (U.S. EPA, 2019a) were used for the dermal contact and mouthing scenarios in younger age groups assessed (*e.g.,* infants, toddlers). This assumption is compounded by the Agency's assumption that all time spent on these activities takes place with articles containing 1,2-dichloroethane. These assumptions ensure that potential risks are not underestimated in the absence of more data on the number and type of consumer articles containing 1,2-dichloroethane that might be present in each home.

EPA considered both variability and uncertainty in this consumer and indoor air exposure assessment for 1,2-dichloroethane and describe these below. 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. Variability cannot be reduced but can be characterized. Uncertainty refers to a lack of data or an incomplete understanding of the context of the risk evaluation decision. Uncertainty can be reduced by collecting more or better data. Uncertainty is addressed qualitatively by including a discussion of factors such as data gaps and subjective decisions or instances where professional judgment was used. This consumer and indoor air exposure assessment for 1,2-dichloroethane has inherent challenges due to sources of uncertainty in the analysis. Some examples of uncertainty include use of 1,2-dichloroethane in product formulation, calculation of surface specific 1,2-dichloroethane emission rates, and patterns of consumer use of the articles evaluated. Variability in environmental conditions can also alter physical and/or chemical behavior of the product or article.

Following consideration of the weight of scientific evidence through documenting the uncertainties and variabilities associated with this consumer and indoor air exposure assessment for 1,2-dichloroethane, EPA presents its confidence (robust, moderate, or slight) in the results and findings. 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. 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 uncertainties that may need to be considered. The confidence to use the results from this consumer and indoor air exposure assessment for 1,2-dichloroethane for risk characterization and regulatory decision-making ranges from moderate to robust after considering the weight of scientific evidence. The basis for the moderate to robust confidence in the overall exposure estimates is a balance between using parameters that represent various populations, use patterns, and health protective assumptions that are not outliers, excessive, or unreasonable.

Product Formulation and Composition
Data were generally limited for weight fractions of 1,2-dichloroethane in consumer goods. EPA obtained data for 1,2-dichloroethane weight fractions in a single plastic ornament as well as emission rates of 1,2-dichloroethane from several similar ornaments, a molded plastic lamp base, and squishy toys from existing literature (Section 2.3). However, the extent to which these specific items or other similarly formulated items include 1,2-dichloroethane in its product formulation or degree of availability in the U.S. market is not well understood. Furthermore, no specific information on the role of 1,2-dichloroethane in polymer formulation for the identified items was available leaving the source of 1,2-dichloroethane emissions from these consumer articles uncertain though emissions of 1,2-dichloroethane were directly measured. Because data were limited, EPA was generally not able to obtain multiple values for weight fraction or emission rates for similar products or articles beyond those utilized for this assessment. Overall weight fraction and/or emission rate confidence is moderate for the articles modeled.

Article Surface Area
The surface area of an article directly affects the potential for 1,2-dichloroethane emissions to the environment. For each article modeled for inhalation exposure, an estimate for surface area was calculated for representative articles or a collection of articles (Section 2.4.2). This approach relied on manufacturer-provided dimensions or product dimensions provided in literature where possible. For small items that might be expected to be present in a home in significant quantities, such as squishy toys, aggregate values were calculated for the cumulative surface area for each type of article in the indoor environment. For example, ornaments were observed for sale from U.S. online retailers in packs of 12. As such, the surface area was adjusted to account for the possibility that multiple ornaments are purchased and enter a home simultaneously. Although aggregate inhalation exposure can occur from multiple articles present in the residence, dermal and oral exposures are limited to the number of articles played with at a given time. For example, an infant only has two hands and therefore can only obtain dermal contact from the number of squishy toys or Christmas ornaments that can be held in both hands (*i.e.,* most likely 1 or 2, rather than 10). Because of this difference across routes and the available data considered, overall confidence in surface area is moderate to robust**.**

Human Behavior
To calculate inhalation exposure, home occupants are assumed to move about the house in activity patterns that take them in and out of the zone in which articles are placed. The activity pattern model used in this assessment assumes that all occupants are at home most of the day. This activity pattern was developed based on the Consolidated Human Activity Database (CHAD) and selected to provide exposure estimates that may be appropriate for individuals who spend significant quantities of time inside the home, such as those who work or attend school from home or those with disabilities that limit mobility (U.S. EPA, 2024a).

Mouthing durations are a source of uncertainty in human behavior. The data used in this assessment are based on a study in which parents observed children (n = 236) ages 1 month to 5 years of age 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 life stage. 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 0 minutes with a maximum of 227 minutes per day. The observers noted that the items mouthed were made of plastic roughly 50% of the mouthing time, but this is not limited to soft plastic items likely to contain significant plasticizer 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). While squishy toys may appropriately fit into toys considered in these studies, the mouthing of Christmas ornaments daily for the entire playtime of 127 minutes for this consumer and indoor air exposure assessment likely adds additional uncertainty as the Christmas ornaments are not typical toys or objects played with by the younger age groups evaluated in this assessment. Nonetheless, EPA maintains the mouthing durations used in this assessment provide a health protective, upper-bound exposure estimates of oral exposure (via mouthing of plastic items found to contain 1,2-dichloroethane). The overall confidence in the values considered for human exposure in this assessment is robust**.**

Modeling Tool

Confidence in the model used considers whether the model has been peer reviewed, as well as whether it is being applied in a manner appropriate to its design and objective. For example, the use of IECCU 1.1 for TSCA risk evaluations has undergone previous peer review through the Science Advisory Committee on Chemicals (SACC) review of the 1-bromopropane (1-BP), cyclic aliphatic bromide cluster (HBCD), and formaldehyde risk evaluations (U.S. EPA, 2024b, 2020a, c). IECCU 1.1 is also publicly available and has been applied for this 1,2-dichloroethane consumer and indoor air exposure assessment in a manner intended and used to estimate exposures associated with articles placed in a residence. This assessment also considers representative user defined input values that can be appropriately applied to existing residences such as building and room volumes, interzonal ventilation rates, and air exchange rates. Overall confidence in the proper use of IECCU 1.1 for this consumer and indoor air exposure assessment for 1,2-dichloroethane is robust.

Dermal Modeling for 1,2-Dichloroethane

Experimental dermal uptake data for 1,2-dichloroethane were not identified via the systematic review process. This provides uncertainty in the characterization of dermal exposures to 1,2-dichloroethane emitted from solid items. To maintain a health protective approach to evaluating dermal exposures to 1,2-dichloroethane from the three articles evaluated in this assessment, EPA assumes 100% absorption of all 1,2-dichloroethane emitted from the object in contact with skin. The Agency acknowledges this assumption likely results in an upper-bound estimate of dermal exposure, but believes it appropriately maintains a health protective approach to assessing dermal exposure. Overall confidence in the dermal uptake values for this 1,2-dichloroethane consumer and indoor air exposure assessment is moderate.

Modeling Parameters for 1,2-Dichloroethane Chemical Migration

EPA did not identify any existing studies examining oral exposure to 1,2-dichloroethane via mouthing or chemical migration rates of 1,2-dichloroethane to saliva. The physical-chemical properties of 1,2-dichloroethane significantly influence its partitioning into saliva during mouthing activities. There is interplay between solubility and volatility around 1,2-dichloroethane that could affect the total dose available for oral absorption followed by swallowing/ingestion of 1,2-dichloroethane absorbed. For example, as a VOC with relatively low molecular weight (98.95 g/mol) and moderate water solubility (8,600 mg/L at 25 °C), 1,2-dichloroethane can readily dissolve in aqueous media like saliva. However, due to its high volatility, 1,2-dichloroethane tends to readily volatilize from an aqueous media; thus, for the oral exposure scenario due to mouthing could reduce the overall concentration retained in saliva over time before it is swallowed or absorbed through mucosal membranes. EPA reduces the volatility component of the uncertainty by assuming a closed mouth mouthing scenario in which even if 1,2-dichloroethane volatilizes from saliva within the mouth it would remain within the oral cavity and be available for ingestion (or inhalation of 1,2-dichloroethane within the oral cavity). The Agency acknowledges the assumption that 100% of emitted 1,2-dichloroethane during mouthing activity is retained in the saliva and ingested likely results in an upper-bound estimate of oral exposure due to mouthing, but believes this assumption appropriately maintains a health protective approach *to assessing oral exposure of 1,2-dichloroethane from the consumer articles evaluated. EPA has moderate* confidence in the total dose estimated during mouthing.

For 1,2-dichloroethane emissions modeling, EPA found that similar ornaments were observed for sale from U.S. online retailers in packs of a dozen. As such, the surface area was adjusted to account for the possibility that multiple ornaments are purchased and enter a home simultaneously. The modeled exposure scenario is therefore representative of the 1-year period evaluated for this exposure assessment and provides a health protective estimate for the first year of use (initial opening of new Christmas ornament for use followed by open/unsealed storage). Likewise, emission estimate for the plastic lamp based also represents use of a newly opened plastic lamp base.

Lastly, the results presented in Section 3.1 for squishy toys do not capture the typical emission rate decay expected from articles like squishy toys. Although use of a constant emission rate model may provide a high-end exposure scenario for consumers who may only introduce a single or multiple squishy toys into the home, it may still represent an average exposure scenario for individuals who may introduce new squishy toys into the home on a routine basis.

5.2 Modeling Approach and Key Parameters for Estimating Dermal Exposure

Dermal exposure to 1,2-dichloroethane from Christmas ornaments and squishy toys were evaluated in this assessment. EPA modeled dermal exposures assuming transfer of emitted 1,2-dichloroethane directly to skin during contact. Key parameters for this exposure modeling approach include the following: surface specific emission rate ($\mu g/cm^2$-h), contact time (h), contact surface area (cm^2), and contact frequency (day^{-1}, $year^{-1}$). For this high-end screening assessment, EPA assumed all surface specific emissions of 1,2-dichloroethane to the hands were fully absorbed. This represents an upper-bound exposure scenario and assumes objects are gripped tightly with little room for diffusion to the air.

To estimate contact time for squishy toys, data were obtained from Table 16-26 of EPA's *Children's Exposure Factors Handbook* (U.S. EPA, 2008). Reported values for playtime for children under 15 years of age ranged from 24 to 137 minutes per day, with a mean value of 88 minutes. The maximum value of 137 minutes per day was selected to estimate exposure for both Christmas ornaments and squishy toys.

Therefore, while out for use during the holiday season and available for play, the exposure scenario presented assumes 30-days of contact and represents an upper-bound exposure estimate. Squishy toys are traditionally intended to be out and available for play daily throughout the year. Therefore, EPA assumes contact frequency for a squishy toy was every day (365 days per year).

Oral exposure to 1,2-dichloroethane due to mouthing from Christmas ornaments and squishy toys were evaluated in this assessment. EPA modeled oral exposures assuming transfer of emitted 1,2-dichloroethane directly to the oral cavity during mouthing. Emissions were assumed to fully transfer to saliva and be ingested, in a closed mouth, mouthing scenario.

Mouthing Duration

Mouthing durations were obtained from Table 4-23 of EPA's *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. Values are provided for toys, pacifiers, fingers, and other objects. EPA did not identify article specific information for mouthing duration for Christmas ornaments and therefore used the mouthing duration values for “other objects” for this exposure assessment. Squishy toys can reasonably be characterized as toys and so the mouthing duration values for “toys” were used for squishy toys. To calculate mouthing durations for each age group in this assessment, all relevant data in Table 4-23 of the Handbook (U.S. EPA, 2011b) were considered together. The maximum value observed across all relevant age groups was used to populate exposure scenarios and is summarized in Table 2-2.

While the mouthing duration values presented in Table 2-2 for “other objects” used for Christmas ornaments are lower than those for “toys” for the age group less than 1 year of age, the values for “other objects” in the remaining age groups are considerably higher than those for “toys.” This is particularly prevalent in the highest age group (3–5 years). The reason for this difference is unknown but may be tied to the type of “other objects” the older age groups may mouth including objects associated with eating (*e.g.,* lollipops, kids plastic eating utensils) or other object designed for longer mouthing durations as well as newer “toys” designed for the older age groups which do not lend themselves as much to mouthing events. These unknown factors in addition to the uncertainty associated with whether a Christmas ornament would be handled and mouthed for the full durations assumed for this assessment further support the estimated oral exposures for Christmas ornaments being an upper-bound limit on potential exposure.

6 CONCLUSIONS

In reviewing peer-reviewed literature, EPA identified evidence of three consumer articles (Christmas ornaments, molded plastic lamp base, and squishy toys) that contain and emit 1,2-dichloroethane, are available in the U.S. market, and are categorized under the COU "Plastic or rubber articles not otherwise classified." Based on the emissions data available for the three consumer articles identified, the Agency evaluated consumer and indoor air exposures from these three articles via the inhalation, dermal, and oral routes of exposure for multiple age groups. Exposures were evaluated for acute, intermediate, and chronic exposure durations as defined for this assessment in Section 2.7.

Results from EPA's assessment of 1,2-dichloroethane found the highest estimated exposures were for the infant age group. The article contributing to the highest acute inhalation, dermal, and oral (mouthing) exposures to 1,2-dichloroethane in infants was attributed to Christmas ornaments. The highest intermediate and chronic inhalation exposures to infants are from emissions from lamp bases whereas dermal and oral (mouthing) exposures are highest from ornaments. Based on the available data and the corresponding exposure estimates, EPA has robust confidence that the consumer exposure scenarios represent a conservative upper bound on exposure.

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