United States
Environmental Protection Agency

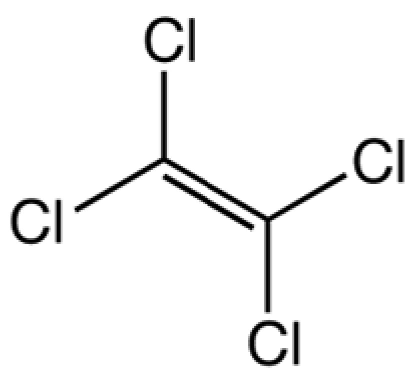
Office of Chemical Safety and
Pollution Prevention

Final Risk Evaluation for Perchloroethylene

Supplemental File:

Perchloroethylene Exposure from Consumer Products and Articles

CASRN: 127-18-4



December 2020

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1 Consumer Products and Articles

This document summarizes EPA's consumer modeling approaches for consumer products and articles containing perchloroethylene (PCE). EPA evaluated PCE exposure resulting from the use of relevant consumer products and consumer articles. A full systematic review of the literature was conducted. PCE concentrations measured in residential air or personal breathing zone samples are reported in Section 2.4.2.1 of the risk evaluation. Monitoring and/or controlled laboratory data were available for a limited number of consumer use scenarios. Where necessary, EPA utilized a modeling approach to estimate perchloroethylene exposure via use of consumer products and articles (Section 2.4.2.2.2).

1.1 Consumer Exposure

Consumer products containing perchloroethylene are readily available at retail stores and via the internet for purchase and use. Use of these products can result in exposures of the consumer user and bystanders to perchloroethylene during and after product use. Consumer exposure can occur via inhalation, dermal, and oral routes.

Consumer products containing perchloroethylene were identified through review and searches of a variety of sources, including the National Institutes of Health (NIH) Household Products Database, various government and trade association sources for products containing perchloroethylene, company websites for Safety Data Sheets (SDS), Kirk-Othmer Encyclopedia of Chemical Technology, and the internet in general. Identified consumer products were then categorized into sixteen consumer use groups considering (1) consumer use patterns, (2) information reported in SDS, (3) product availability to the public, and (4) potential risk to consumers. Table 1-1 summarizes the sixteen consumer use groups evaluated as well as the routes of exposure for which they were evaluated.

Table 1-1. Consumer Uses and Routes of Exposure Assessed

Consumer Uses	CEM Scenario	Routes of Exposure
1. Aerosol Cleaners for Motors; Coils; Electrical Parts; Cables; Stainless Steel; Marine Equipment; Wire and Ignition Demoisturants	Degreasers I	Inhalation and Dermal
2. Parts cleaner	Generic (Liquid Bath)	
3. Brake Cleaner	Degreasers II	
4. Vandalism mark & stain remover; Mold cleaner; Weld splatter protectant	All-Purpose Spray Cleaner	
5. Marble polish; Stone cleaner (liquid)	All-Purpose Liquid Cleaner	
6. Cutting fluid	Non-Spray Lubricant	
7. Spray lubricant; Penetrating oil	Spray Lubricant	
8. Industrial adhesive; Adhesive; Arts and crafts adhesive; Gun ammunition sealant	Glues and Adhesives	
9. Livestock grooming adhesive	Spray Fixative and Coatings	

10. Caulk; Sealant; Column Adhesives	Caulk	
11. Coatings; Primers (aerosol)	Aerosol Spray Paint	
12. Rust primer; Sealant	Solvent-Based Wall Paint I	
13. Metallic overglaze (ceramics)	Lacquers and Stains	
14. Sealant (outdoor water shield)	Solvent-Based Wall Paint II	
15. Stone cleaner; Marble polish (wax)	All-Purpose Waxes and Polishes	
16. Dry Cleaning (vapor, articles)	Article Diffusion (dermal); (MCCEM was use for inhalation estimation)	

The U.S. EPA evaluated acute inhalation and dermal exposure of the consumer to perchloroethylene for this evaluation. Acute inhalation exposure is an expected route of exposure for all sixteen consumer use groups. Acute dermal exposure is also a possible route of exposure for sixteen consumer use groups. The U.S. EPA does not expect exposure under any of the sixteen consumer use groups evaluated to be chronic in nature and therefore does not present chronic exposure for consumers. The U.S. EPA does not expect oral exposure to occur under any of the sixteen consumer use groups evaluated and therefore did not evaluate the oral route of exposure.

The U.S. EPA evaluated inhalation and dermal exposure for the consumer user and evaluated only inhalation exposure for a non-user (bystander) located within the residence during product use. The consumer user consisted of three age groups (adult, greater than 21 years of age; Youth 16-20 years of age; and Youth 11-15 years of age) which includes the susceptible population woman of childbearing age. The bystander can include individuals of any age (infant through elderly).

1.2 Consumer Modeling

The model used to evaluate consumer exposures was EPA's Consumer Exposure Model (CEM). Table 1-2 summarizes the specific models used for each consumer use group and the associated routes of exposure evaluated.

Table 1-2. Models Used for Routes of Exposure Evaluated

Consumer Uses	Routes of Exposure	
	Inhalation	Dermal
1. Cleaners for Motors; Coils; Electrical Parts; Cables; Stainless Steel; Marine Equipment; Wire and Ignition Demoisturants (aerosol)	CEM	CEM
2. Parts cleaner (liquid)	CEM	CEM
3. Brake Cleaner (aerosol)	CEM	CEM

Consumer Uses	Routes of Exposure	
	Inhalation	Dermal
4. Vandalism mark & stain remover; Mold cleaner; Weld splatter protectant (aerosol)	CEM	CEM
5. Marble and stone polish (liquid)	CEM	CEM
6. Cutting fluid (liquid)	CEM	CEM
7. Spray lubricant; Penetrating oil (aerosol)	CEM	CEM
8. Industrial adhesive; Adhesive; Arts and crafts adhesive; Gun ammunition sealant (liquid)	CEM	CEM
9. Livestock grooming adhesive (aerosol)	CEM	CEM
10. Caulk; Sealant; Column adhesive; (gel/liquid)	CEM	CEM
11. Coatings; Primers (aerosol)	CEM	CEM
12. Rust primer; Sealant (liquid)	CEM	CEM
13. Metallic overglaze (liquid)	CEM	CEM
14. Sealant (outdoor water shield) (liquid)	CEM	CEM
15. Stone cleaner; Marble polish (gel/wax)	CEM	CEM
16. Dry Cleaning (vapor, articles)	MCCEM	CEM

Readers are referred to each model's user guide and associated user guide appendices for details on each model, as well as information related to equations used within the models, default values, and the basis for default values. Each model is peer reviewed. Default values within CEM are a combination of high end and mean or central tendency values derived from U.S. EPA's Exposure Factors Handbook, literature, and other studies.

1.3 CEM Approach

CEM is a deterministic model which utilizes user provided input parameters and various assumptions (or defaults) to generate exposure estimates. In addition to pre-defined scenarios, which align well with the sixteen consumer uses identified in Table 2-1, CEM is peer reviewed, provides flexibility to the user allowing modification of certain default parameters when chemical-specific information is available and does not require chemical-specific emissions data (which may be required to run more complex indoor/consumer models).CEM predicts indoor air concentrations from consumer product use through a deterministic, mass-balance calculation derived from emission calculation profiles within the model. There are six emission calculation profiles within CEM (E1-E6) which are summarized in the CEM users guide and associated appendices (U.S. EPA 2019). If selected, CEM provides a time series air concentration profile for each run. These are intermediate values produced prior to applying pre- defined activity patterns. CEM uses a two-zone representation of the building of use when predicting indoor air concentrations. Zone 1 represents the room where the consumer product is used. Zone 2 represents the remainder of the building. Each zone is considered well mixed. CEM allows further division of Zone 1 into a near field and far field to accommodate situations where a higher concentration of product is expected very near the product user when the product is used. Zone 1-near field represents the breathing zone of the user at the location of the product use while Zone 1 far field represents the remainder of the Zone 1 room.

Inhalation exposure is estimated in CEM based on zones and pre-defined activity patterns. The simulation run by CEM places the product user within Zone 1 for the duration of product use while the bystander is placed in Zone 2 for the duration of product use. Following the duration of product use, the user and bystander follow one of three pre-defined activity patterns established within CEM, based on modeler selection. The selected activity pattern takes the user and bystander in and out of Zone 1 and Zone 2 for the period of the simulation. The user and bystander inhale airborne concentrations within those zones, which will vary over time, resulting in the overall estimated exposure to the user and bystander.

CEM contains two methodologies for estimating dermal exposure to chemicals in products applied to skin, the permeability method (P-DER2b) and the fraction absorbed method (P-DER2a). Each methodology has associated assumptions, uncertainties anddata input needs within the CEM model. Both methodologies factor in the dermal surface area to body weight ratio and weight fraction of chemical in a consumer product.

The permeability model is based on the ability of a chemical to penetrate the skin layer once contact occurs. The permeability model assumes a constant supply of chemical, directly in contact with the skin, throughout the exposure duration. The ability to use the permeability method can be beneficial when chemical-specific skin permeability coefficients are available in the scientific literature. However, the permeability model within CEM does not consider evaporative losses when it estimates dermal exposure and therefore may be more representative of a dermal exposure resulting from a constant supply of chemical to the skin due to a barrier or other factor that may restrict evaporation of the chemical of interest from the skin (a product soaked rag against the hand while using a product), or immersion of a body part into a pool of product. Either of these examples has the potential to cause an increased duration of dermal contact and permeation of the chemical into the skin resulting in dermal exposure.

The fraction absorbed method is based on the absorbed dose of a chemical. This method essentially measures two competing processes, evaporation of the chemical from the skin and penetration of the chemical deeper into the skin. This methodology assumes the application of the chemical of concern occurs once to an input thickness and then absorption occurs over an estimated absorption time. The fraction absorbed method can be beneficial when chemical specific fractional absorption measurements are available in the scientific literature. The consideration of evaporative losses by the fraction absorbed method within CEM may make this model more representative of a dermal exposure resulting from scenarios that allow for continuous evaporation and typically would not involve a constant supply of product for dermal permeation. Examples of such scenarios include spraying a product onto a mirror and a small amount of mist falling onto an unprotected hand.

All consumer use groups identified in Table 2-2 and evaluated with CEM used CEM's E1, E2, E3, or E5 emission model and profile for inhalation exposure. For the E1 emission model, the model assumes a constant application rate over a user-specified duration of use. Each instantaneously applied segment has an emission rate that declines exponentially over time, at a rate that depends on the chemical's molecular weight and vapor pressure. For the E2 emission model, the model assumes an initial fast release by evaporation followed by a slow release dominated by diffusion. The E3 emission model assumes a percentage of a consumer product used is aerosolized (e.g. overspray) and therefore immediately available for uptake by inhalation. Finally, the E5 model is for products that are placed in the environment but not added to water. The U.S. EPA also used the near-field and far-field option within CEM for all consumer use groups evaluated with CEM. For dermal exposure within CEM, the permeability method model, P-DER2b was used for the sixteen consumer scenarios, but results were presented for only those COUs where limited evaporation was a reasonable assumption, due to the use of a solvent soaked rag held in a hand or immersive parts cleaning.

In an effort to characterize a potential range of consumer inhalation exposures, the EPA varied three key parameters within the CEM model while keeping all other input parameters constant. The key parameters varied were duration of use per event (minutes/use), amount of chemical in the product (weight fraction), and mass of product used per event (gram(s)/use). These key parameters were varied because they provide representative consumer behavior patterns for product use. Additionally, CEM is highly sensitive to two of these three parameters (duration of use and weight fraction). A summary of a sensitivity analysis performed of CEM is provided in Appendix E with details provided within the CEM users guide and associated CEM user guide appendices. Finally, all three parameters had a range of documented values within literature identified as part of Systematic Review allowing the EPA to evaluate inhalation exposures across a spectrum of use conditions.

To characterize a potential range of consumer dermal exposures, the EPA varied two key parameters within CEM while keeping all other input parameters constant. The key parameters varied for dermal exposure evaluation were weight fraction and duration of use per event. The mass of product used is not a factor in the dermal exposure equations within CEM and therefore was not varied.

Once the data was gathered for the parameters varied, modeling was performed to cover all possible combinations of these three parameters. This approach results in a maximum of 27 different iterations for each consumer use. Certain uses, however, only had a single value for one or more of the parameters varied which reduces the total number of iterations.

Post-processing to determine personal concentration exposures for the user and bystander was conducted by independently assigning the Zone 1, Zone 2, and outside (zero) concentration to the user and bystander. These zone concentrations were assigned based on the pre-defined activity patterns within CEM. Time-weighted average concentration exposures were then calculated from the personal exposure time series for each base case and scaled to develop estimates for all iterations within each consumer use category. Time weighted averages (TWA) were determined for 1 hour, 3 hours, 8 hours, and 24 hours, although for this evaluation the 24-hour TWA concentration was utilized based on health endpoints used to calculate risks.

1.4 CEM Inputs

Numerous input parameters are required to generate exposure estimates within CEM (Table 1-3). These parameters include physical chemical properties of the chemical of concern, product information (product density, water solubility, vapor pressure, etc.), model selection and scenario inputs (pathways, CEM emission model(s), emission rate, activity pattern, product user, background concentration, etc.), product or article property inputs (frequency of use, aerosol fraction, etc.), environmental inputs (building volume, room of use, near-field volume in room of use, air exchange rates, etc.), and receptor exposure factor inputs (body weight, averaging time, exposure duration inhalation rate, etc.). Several of these input parameters have default values within CEM based on the pre-defined use scenario selected. Default parameters within CEM are a combination of high end and mean or median values found within the literature or based on data taken from U.S. EPA's Exposure Factors Handbook (U.S. EPA 2011). Details on those parameters can be found within the CEM Users Guide and associated Users Guide Appendices at (U.S. EPA 2019), or can be cross referenced to U.S. EPA's Exposure Factors Handbook (U.S. EPA 2011). As discussed earlier, while default values are initially set in pre-defined use scenarios, CEM has flexibility which allows users to change certain pre-set default parameters and input several other parameters.

Key input parameters for the sixteen consumer uses identified in Table 2-4 evaluated with CEM are discussed below. Detailed tables of all input parameters used for each consumer use evaluated with CEM are provided in the *Draft Risk Evaluation for Perchloroethylene (PCE) Supplemental File: Consumer Exposure Assessment Model Input Parameters* (supplemental file #22).

Physical chemical properties of perchloroethylene were kept constant across all consumer uses and iterations evaluated. The saturation concentration in air (one of the factors considered for scaling purposes) was estimated by CEM as 1.65E+05 milligrams per cubic meter. A chemical-specific skin permeability coefficient of 0.018 centimeters per hour was estimated within CEM and utilized for all scenarios modeled for dermal exposure.

Model selection is discussed in the previous section (CEM modeling approaches). Scenario inputs were also kept constant across all consumer uses and iterations. Emission rate was estimated using CEM. The activity pattern selected within CEM was stay-at-home. The start time for product use was 9:00 AM and the product user was adult (>21 years of age) and Youth (16 through 20 years of age). The background concentration of perchloroethylene for this evaluation was considered negligible and therefore set at zero milligrams per cubic meter.

Frequency of use for acute exposure calculations was held constant at one event per day. The aerosol fraction (amount of overspray immediately available for uptake via inhalation) selected within CEM for all consumer uses evaluated was six percent. Building volume used for all consumer uses was the default value for a residence within CEM (492 cubic meters). The near-field volume selected for all consumer uses was one cubic meter. Averaging time for acute exposure was held constant at one day.

Certain model input parameters were varied across consumer use scenarios but kept constant for all model iterations run for that particular consumer use. These input parameters include product density, room of use, and pre-defined product scenarios within CEM. Product densities were extracted from product-specific SDS. Room of use was extracted from an EPA directed survey of consumer behavior patterns in the United States titled Household Solvent Products: A National Usage Survey(Westat 1987) (Westat Survey), identified in the literature search as part of systematic review. The Westat survey is a nationwide survey which provides information on product usage habits for thirty-two different product categories. The information was collected via questionnaire or telephone from 4,920 respondents across the United States.

The Westat Survey was rated as a high-quality study during data evaluation within the systematic review process. The room of use selected for this evalution is based on the room in which the Westat Survey results reported the highest percentage of respondents that last used a product within the room. When the Westat Survey identified the room of use where the highest percentage of respondents last used the product as "other inside room", the utility room was selected within CEM for modeling. The pre-defined product scenarios within CEM were selected based on a cross-walk to similar product categories within the Westat Survey. A crosswalk between the perchloroethylene Consumer Use Scenarios and the corresponding Westat product category selected to represent the exposure scenario is provided below. In instances where a pre-defined product was not available within CEM, a generic model scenario was assigned in CEM with would run the requisite inhalation, emission, and dermal models.

Table 1-3. Crosswalk Between perchloroethylene Consumer Use Scenarios and Westat Product Category

Perchloroethylene Consumer Use Scenario	Representative Westat Product Category
1. Aerosol Cleaners for Motors; Coils; Electrical Parts; Cables; Stainless Steel; Marine Equipment; Wire and Ignition Demoisturants	Solvent-Type Cleaning Fluids Or Degreasers
2. Parts Cleaner	Spot Removers
3. Brake Cleaner	Brake Quieters/Cleaners
4. Vandalism Mark & Stain Remover; Mold Cleaner; Weld Splatter Protectant	Solvent-Type Cleaning Fluids Or Degreasers
5. Marble Polish; Stone Cleaner (liquid)	Solvent-Type Cleaning Fluids Or Degreasers
6. Cutting Fluid	Other Lubricants (Excluding Automotive)
7. Spray Lubricant; Penetrating oil	Other Lubricants (Excluding Automotive)
8. Industrial Adhesive; Adhesive; Arts and Crafts Adhesive; Gun Ammunition Sealant	Contact Cement, Super Glues, And Spray Adhesives
9. Livestock Grooming Adhesive	Contact Cement, Super Glues, And Spray Adhesives
10. Caulk; Sealant; Column Adhesive	Primers And Special Primers (Excluding Automotive)
11. Coatings; Primers (aerosol)	Aerosol Spray Paint
12. Rust Primer; Sealant	Primers And Special Primers (Excluding Automotive)
13. Metallic Overglaze	Contact Cement, Super Glues, And Spray Adhesives
14. Sealant (Outdoor Water Shield)	Outdoor Water Repellent
15. Stone Cleaner; Marble Polish (wax)	Solvent-Type Cleaning Fluids Or Degreasers
16. Dry Cleaning (vapor, articles)	N/A

Additional key model input parameters were varied across both consumer use scenario and model iterations. These key parameters were duration of use per event (minutes/use), amount of chemical in the product (weight fraction), and mass of product used per event (gram(s)/use). Duration of use and mass of product used per event values were both extracted from the Westat Survey (Westat 1987). To allow evaluation across a spectrum of use conditions, the EPA chose the Westat Survey results for these two parameters from the above cross-walked product categories representing the tenth, fiftieth (median), and ninety-fifth percentile data, as presented in the Westat Survey.

The amount of chemical in the product (weight fraction) was extracted from product specific SDS. This value was varied across the given range of products within the same category to obtain three values, when available. Unlike the Westat survey results which gave percentile data, however, product specific SDS across products did not have percentile data so the values chosen represented the lowest weight fraction, mean weight fraction (of the range available), and the highest weight fraction found. Even using this approach, some SDS were only available for a single product with a single weight fraction or very small range, or multiple products which only provided a single weight fraction or a very small range. For these product scenarios, only a single weight fraction was used in CEM for modeling. The following table summarizes the input parameter values used for these three parameters by consumer use.

Table 1-4. Model Input Parameters Varied by Consumer Use

Consumer Use	Duration of Use (minutes/use)			Mass of Product Used (gram(s)/use)			Amount of Chemical In Product (weight fraction)		
	10th	50th	95th	10th	50th	95th	Low	Mean	High
AEROSOL Cleaners for Motors; Coils; Electrical Parts; Cables; Stainless Steel; Marine Equipment; Wire and Ignition Demoisturants	2.0	15.0	120.0	26.83	155.69	1532.91	0.1	0.8	1
Parts cleaner	0.25	5.00	30.00	9.91	52.70	441.01	0.5	0.6	
Brake Cleaner	1.0	15.0	120.0	39.03	156.13	624.52	0.4	0.91	1
Vandalism mark & stain remover; Mold cleaner; Weld splatter protectant	2.0	15.0	120.0	26.83	155.69	1532.91	0.05	0.40	1
Marble polish	2.0	15.0	120.0	61.88	330.05	1608.99	0.10	0.85	1
Cutting fluid	0.08	2.00	30.00	26.83	155.69	1532.91	0.1 (single)		
Spray Lubricant; Penetrating oil	0.08	2.00	30.00	4.79	26.35	239.52	0.05	0.54	1
Industrial adhesive; Adhesive; Arts and crafts adhesive; Gun ammunition sealant	0.33	4.25	60.00	1.16	9.68	167.34	0.3	0.89	1
Livestock grooming adhesive	0.33	4.25	60.00	1.29	10.72	185.23	0.15		
Caulk; Sealant; Column adhesive	5.0	30.0	360.0	45.39	387.07	8121.46	0.05	0.48	0.75
Coatings; Primers	5.0	20.0	120.0	61.88	330.05	1608.99	0.09	.010	0.14
Rust primer; Sealant	5.0	30.0	360.0	53.22	453.82	9521.90	0.09	0.1	0.11
Metallic overglaze	0.33	4.25	60.00	0.89	7.39	127.74	0.2	0.3	
Sealant (water shield)	15.0	60.0	300.0	302.80	2422.37	24223.74	0.45		
Stone cleaner; Marble polish	2.0	15.0	120.0	23.18	134.54	1324.74	0.85	0.95	1

1.5 MCCEM Approach

1.5.1 Basis for Modeling Analysis

The setup of the modeling analysis was based on papers by Tichenor (1990) and Sherlach (2011), which were identified as high-quality and most relevant during systematic literature review. The Tichenor (1990) authors were affiliated with EPA's Indoor Air Branch (Air and Energy Engineering Research Laboratory, Research Triangle Park, NC). They measured perchloroethylene concentrations in a small chamber and in a test house due to off-gassing from 12 freshly dry-cleaned fabrics – Arnel (triacetate), Acetate (diacetate), Polypropylene, Spun Dacron 54, Spun Dacron 64, Polyester double knit, Nylon 66, Orlon, Acrilan, Wool, and Fiberglass – under different conditions (in a bag, out of a bag, and aired out). The authors fit a model to the emissions and included a reversible sink in an attempt to explain the measured concentrations. The objectives for this modeling exercise were (1) to determine whether the measurements in the EPA test house could be reasonably matched and (2) if so, to extend the model to a generic house as a basis for estimating exposures for the dry-cleaning scenario(s). The Sherlach (2011) study measured residual PCE retained in wool, polyester, cotton and silk fabrics cleaned at five different commercial dry cleaners using PCE as the cleaning solvent. Concentrations of PCE retained in fabrics were measured by GC/MS immediately after single dry-cleaning cycles and after each of six repeat dry-0cleaning cycles, for each fabric type, at each dry-cleaning establishment.

The EPA test house layout, shown in Figure 1 from the Tichenor (1990) paper on the next page, was used to develop volumes for the zone of use (closet), adjacent zone (bedroom), and the rest of house (ROH). Tichenor et al. did not report include the house volume, individual zone volumes, or airflow rates (although they indicated that air exchange rates were measured). In a separate paper (Chang et al. 1998) by authors from the same EPA branch, the house volume was reported as 305 m3 and the whole-house air exchange rate as 0.5 h-1. Individual room volumes and airflow rates were not reported; room volumes were estimated from the house diagram (closet volume = 3 m^3 and bedroom volume excluding closet = 24 m^3) and the interzonal airflow rate (IAR) between the bedroom and ROH was estimated using the Koontz and Rector algorithm[3]. For the initial modeling step, airflow rates between the closet (near-field zone) and bedroom (far-field zone) were set to 10% of the airflow rate between the bedroom and ROH, as shown in Table ***1-5***.

Table 1-5. MCCEM Airflow Rates (m^3/hr) for the EPA Test House (Volume = 305 m^3)

Zones	OA	Near Field (Closet)	Far Field (Bedroom)	ROH
OA	==	0	12	139
Near Field (Closet)	0	==	7.1	0
Far Field (Bedroom)	12	7.1	--	71
ROH	139	0	71	==

[1] Koontz, MD, and Rector, HR. 1995, Estimation of Distributions for Residential Air Exchange Rates, final report for USEPA Office of Pollution Prevention and Toxics, GEOMET Technologies, Inc. IAR = (0.078 + 0.31*A)*V, where
IAR = Interzonal air exchange rate(m^3/h), A = whole-house air exchange rate (1/h), and V = house volume (m^3).

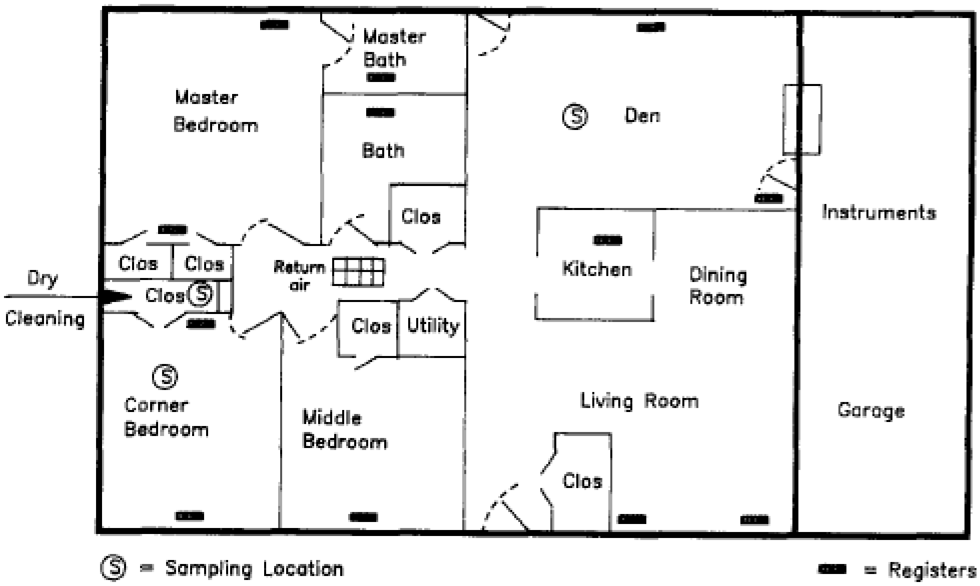


Figure 1. IAQ Test House

In the Tichenor study, the clothes (wool skirt, two polyester/rayon blouses and a two-piece suite) were dry cleaned at a commercial facility where the clothing was bagged, immediately transported to the house, and placed in the closet of the corner bedroom. The closet doors were closed; all other interior doors were opened.

The house air was sampled at three locations (closet, bedroom, and den). Tichenor et al. fit the measured air concentrations to a model that included the following three equations:

(1)

The source term used to model the perchloroethylene emission was based on the small chamber data and is in the form:

$$E(t) = R_0 e^{-kt} A \quad (6)$$

A re-emitting sink was used in the perchloroethylene modeling. The rate going to the sink was assumed to be:

(2)

$$R_s = k_s C_r A_s \quad (7)$$

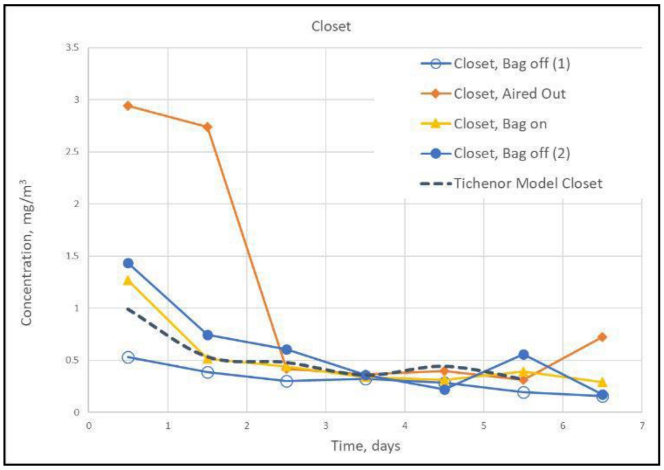
$$E_s = k_e M_s A_s (C_r - C_c), \text{ when } C_r > C_c \quad (8)$$

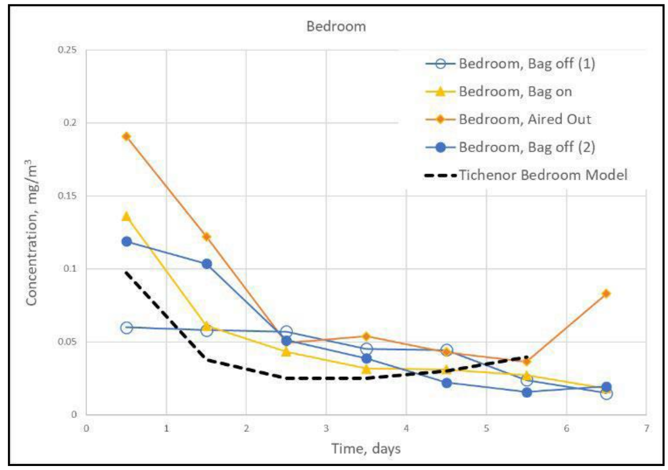
$$E_s = 0, \text{ when } C_r \leqslant C_c \quad (9)$$

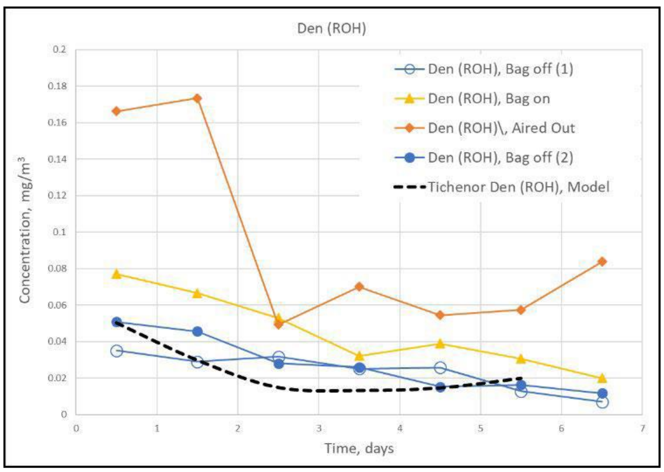
(3)

The first equation is a standard first-order exponential emission model, the second is a first-order sink model, and the third is a concentration-dependent re-emission model.

The three images below show the average daily concentrations extracted from the bar charts presented by Tichenor for the four cases in the closet, bedroom, and den, respectively, as well the concentrations predicted by Tichenor's model:





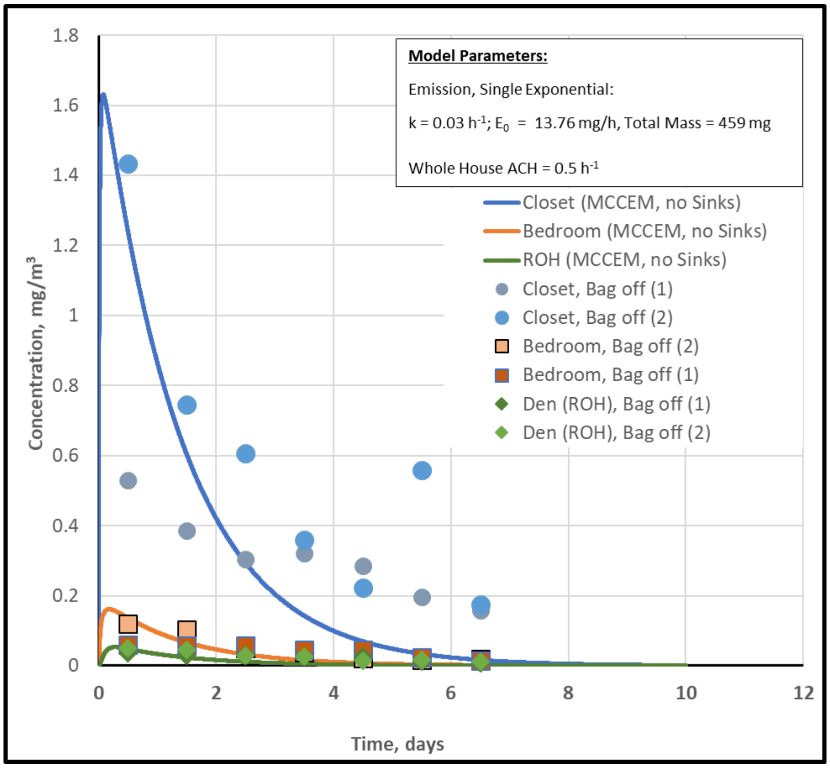


The use of the aired-out case was not chosen because it deviated substantially from the others. For example, at all three sampling locations the concentrations for the first two days for that case were more than double those for all other cases, then dropped to values similar to the other cases for days 3-6 and rose substantially on day 7.

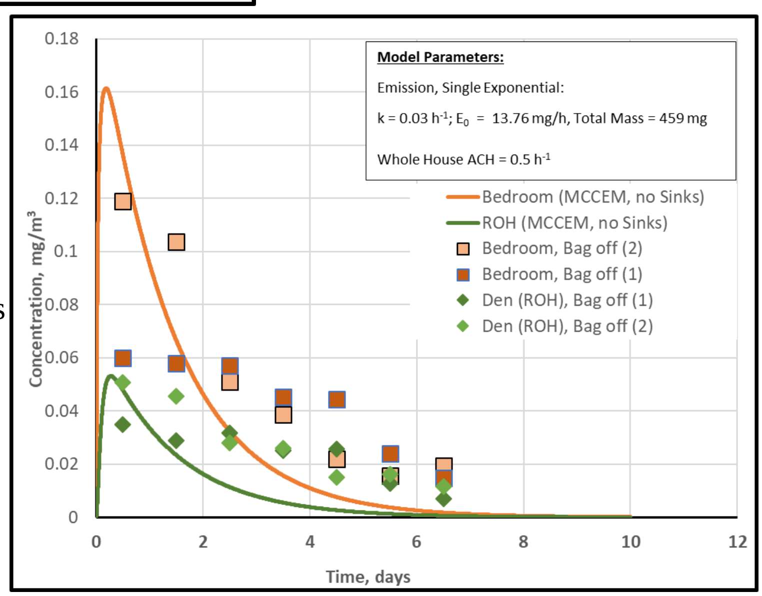
MCCEM does not have the capability of representing the concentration-dependent re-emission model shown above in Tichenor's Equations 8 and 9. Although MCCEM does have a reversible-sink capability based on mass in the sink, that model does not include a concentration-feedback term (C_r-C_c). For these reasons, and because only the concentrations for the aired-out case rose toward the end of the experiments, the fit using only the emission term (i.e., without considering sinks) was initially evaluated, reserving the possibility of using the MCCEM reversible-sink model as a follow-up strategy.

1.5.2 MCCEM Parameterization and Predictions for EPA Test House

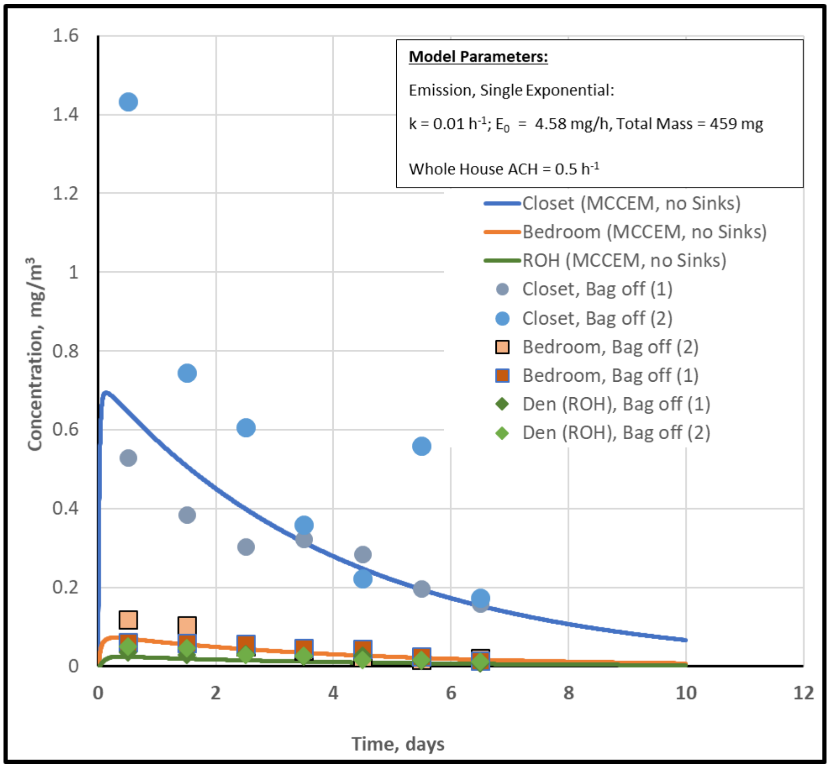
The single-exponential emission model in MCCEM was parameterized with the values from Tichenor's paper (R_0 = 1.6 mg/m^2, k = 0.03/h, A = 8.6 m^2). The initial emission rate (13.76 mg/h) was determined by multiplying R_o by A and the theoretical perchloroethylene mass available for release to the indoor air (459 mg), which can be obtained by integrating Tichenor's Equation 6 from time = 0 to time = ∞, was determined by dividing this initial emission rate by k. As shown in the figures below, the model with these values over predicted the concentrations on day 1 and then declined more rapidly than the measured concentrations, resulting in substantial under prediction from day 3 onward.



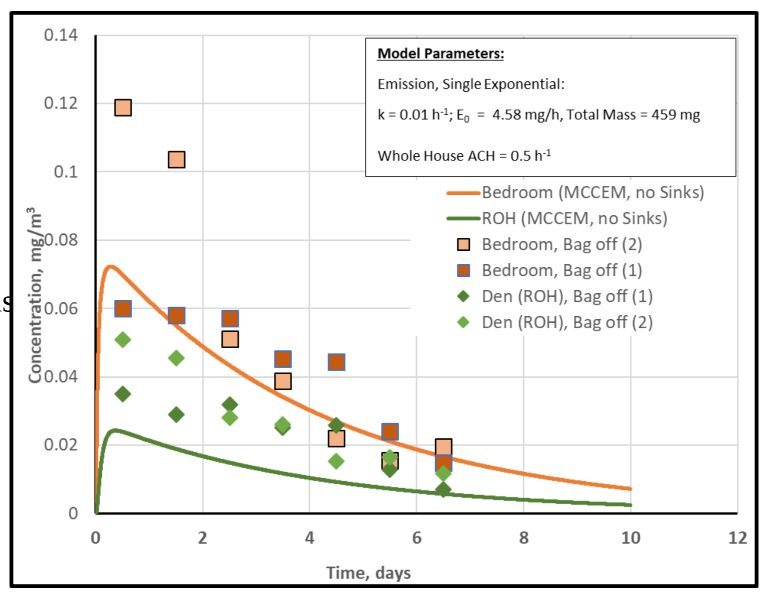
Close-up of Bedroom and Den Concentrations



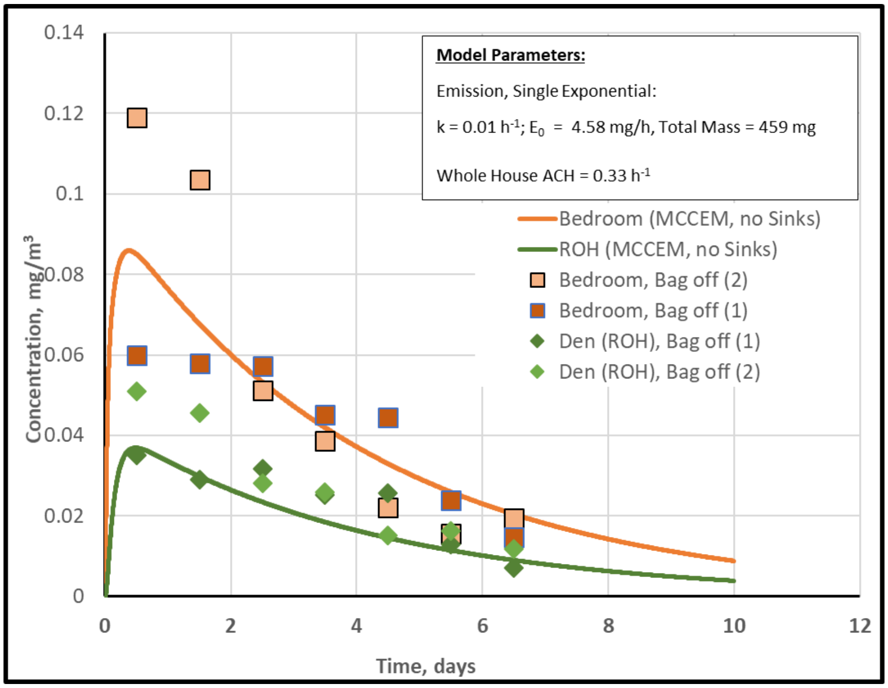
To “slow down” the rapid decline, the value for k was lowered by a factor of three (from 0.03 to 0.01 h^{-1}) while adjusting the initial emission rate to maintain the same theoretical perchloroethylene mass available for release. As shown in the figure below, the model with these values improved the fit somewhat but erred in the opposite direction; that is, with these values the model tended to under predict on the first several days but did come closer to matching the data toward the end of the time series.



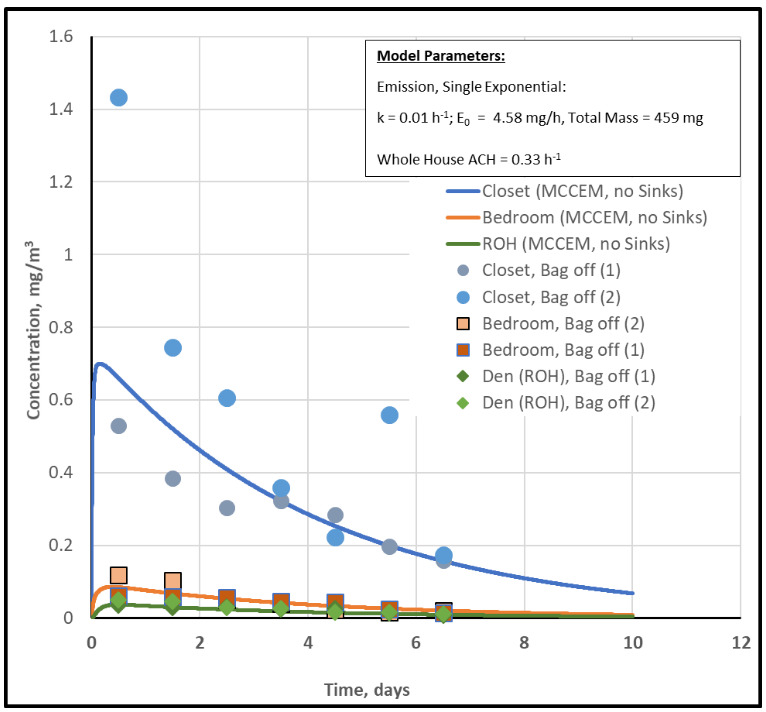
Close-up of Bedroom and Den Concentrations



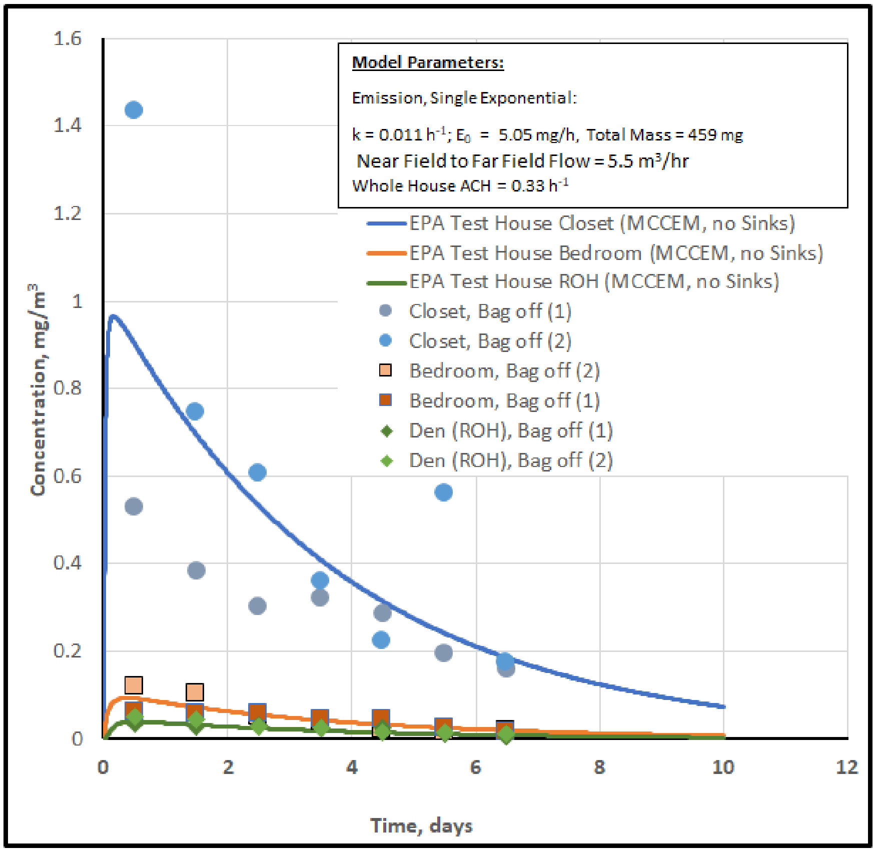
As shown below, lowering the whole-house air exchange rate from 0.5 to 0.33 h^{-1} generally resulted in an improved fit for the bedroom and the ROH, but there still was some under prediction for both the closet and the bedroom concentrations on the first day.



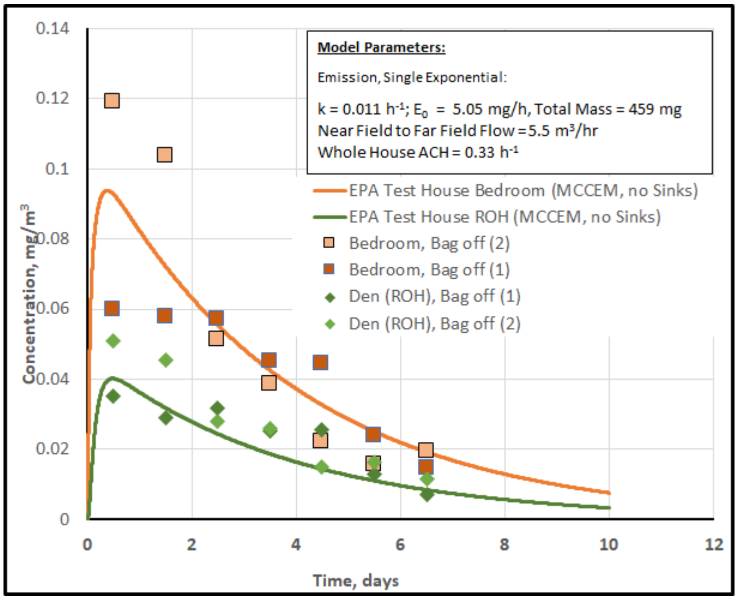
Close-up of Bedroom and Den Concentrations



To “fine tune” the model, several different combinations of k and the closet-bedroom airflow rate were tried, judging the combination of k = 0.011^{-1} and an airflow rate of 5.5 m^3/h to best “split the difference” between the low and high values in both the closet and the bedroom on the first day of the two tests.



Close-up of Bedroom and Den Concentrations



1.5.3 Model Application to Generic House

Because the above modeling approach appeared to fit the data well, it was concluded that the reversible sink could be ignored and the modeling could proceed with a more simplistic representation. This model was then applied to a generic house with the volume (446 m^3) in CEM. The house and zone volumes for this house are shown, in comparison to those for the EPA test house, in the table below.

Table 1-6. EPA VS Generic Test House Zones

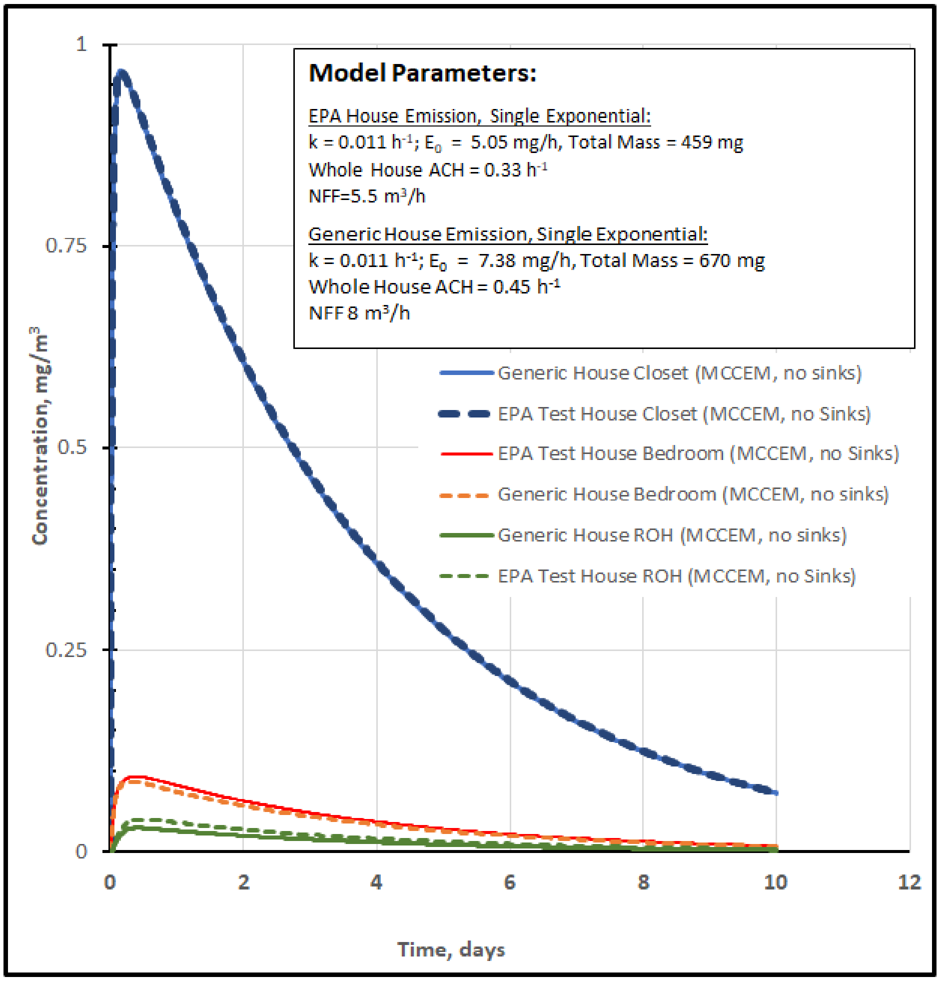
Zone	Zone Volumes (m^3)	
	EPA Test House	Generic House
Near Field (Closet)	3	5
Far Field (Bedroom)	24	31
Rest of House	278	410
TOTAL HOUSE VOLUME	305	446

The airflow rates, summarized in the table below, were scaled up based on house volume (i.e., from the 305-m^3 EPA test house to the 446-m^3 generic house); an air exchange rate of 0.45 hr^{-1} was assumed for consistency with CEM runs.

Table 1-7. MCCEM Air Flows for the Generic House (Volume = 446 m^3)

ZONES	OA	Near Field (Closet)	Far Field (Bedroom)	ROH
OA		0	13.95	184.5
Near Field (Closet)	0		8.0	0
Far Field (Bedroom)	13.95	8.0		97
ROH	184.5	0	97	

The clothes included in the Tichenor test consisted of five items (wool skirt, two polyester/rayon blouses and a two-piece suite) with a combined of 8.6 m^2. As a first approximation, the clothing area by the ratio of house volumes were scaled up (446/305) for a new quantity of 12.6 m^2, adding 4 m^2 of fabric or approximately 2 additional pieces of clothing. As shown in the figure below, predictions for the generic house with scaled-up values were nearly identical to those for the EPA house. The peak predicted air concentration in the closet (~ 1 mg/m^3) is well below the saturation concentration (~ 1.65 E+05 mg/m^3).



1.1.1.1 Modeling Recommendations and Issues

Based on the above analysis, the following are recommended parameters for the MCCEM base case:

> $k = 0.011\ hr^{-1}$ based on the above fit to the Tichenor data
>
> $E_0 = 7.38$ mg/h based on the fitted value to the Tichenor data, adjusted for an increased amount of dry-cleaned clothing.

It is recommended that MCCEM be executed for the generic house base case, as described above. Because the saturation concentration will not be exceeded, the modeling results can be scaled to the desired quantity of clothing for different percentiles of an assumed distribution (to be determined). The mass (i.e., area of clothing) will scale in direct proportion to the initial emission rate, assuming that the rate constant for emissions decay, k, remains constant. Both chronic and acute inhalation dose will scale proportionally to mass, and the chronic dose will scale proportionally to frequency of use.

The CEM activity pattern for a stay-at-home adult for a product/article in the bedroom is recommended as a basis for estimating inhalation exposure for the dry-cleaning scenario, with one added perturbation, namely an assumed small amount of time (e.g., 5 minutes or less) in the morning and in the evening spent in the closet (near field). Based on this adjustment (see highlights), the recommended activity pattern is given in the table below.

Table 1-8. Activity Patterns for the Dry-Cleaning Scenario

			Location	
Start Time	End Time	Stay at Home	Full Time	Part-Time
12:00 AM	1:00 AM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
1:00 AM	2:00 AM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
2:00 AM	3:00 AM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
3:00 AM	4:00 AM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
4:00 AM	5:00 AM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
5:00 AM	6:00 AM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
6:00 AM	7:00 AM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
7:00 AM	7:55 AM	Residence - Bathroom	Residence - Bathroom	Residence - Bathroom
7:55 AM	8:00 AM	Residence - Closet	Residence - Closet	Residence - Closet
8:00 AM	9:00 AM	Automobile	Automobile	Automobile
9:00 AM	10:00 AM	Office/School	Office/School	Office/School
10:00 AM	11:00 AM	Residence - Living Room	Office/School	Office/School
11:00 AM	12:00 PM	Residence - Living Room	Office/School	Office/School
12:00 PM	1:00 PM	Residence - Kitchen	Office/School	Office/School
1:00 PM	2:00 PM	Outside	Office/School	Office/School
2:00 PM	3:00 PM	Residence - Living Room	Office/School	Residence - Living Room
3:00 PM	4:00 PM	Residence - Living Room	Office/School	Residence - Living Room
4:00 PM	5:00 PM	Residence - Utility Room	Office/School	Residence - Utility Room
5:00 PM	6:00 PM	Outside	Outside	Outside
6:00 PM	7:00 PM	Residence - Kitchen	Residence - Kitchen	Residence - Kitchen
7:00 PM	8:00 PM	Residence - Living Room	Residence - Living Room	Residence - Living Room
8:00 PM	9:00 PM	Residence - Living Room	Residence - Living Room	Residence - Living Room
9:00 PM	9:55 PM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
9:55 PM	10:00 PM	Residence - Closet	Residence - Closet	Residence - Bathroom
10:00 PM	11:00 PM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom
11:00 PM	12:00 AM	Residence - Bedroom	Residence - Bedroom	Residence - Bedroom

For youth and child inhalation exposures, one key decision is whether or not to assume that dry-cleaned fabrics would be present in their respective bedrooms; if not, then their bedrooms should be treated as part of the ROH. Alternatively, exposure estimates could be developed for both possibilities. Other key modeling inputs are the perchloroethylene mass (related to assumed number of clothing items) and the frequency with which dry-cleaned clothing is assumed to be brought into the house

The dermal uptake would result primarily from vapor-phase contact, but direct contact (as well as added inhalation exposure) also could occur if any clothing items are worn within the primary off-gassing period of approximately 7 days. The vapor-phase model incorporated in CEM is recommended for use.

$$K_{p\_g} = \left(\frac{1}{V_d} + \frac{1}{K_{p\_b}}\right)^{-1} \tag{77}$$

Where:

K_{p_g}	=	Indoor air transdermal permeability coefficient that describes transport of a gas-phase chemical from air in the core of a room through the boundary layer adjacent to skin and then through the stratum corneum/viable epidermis composite to dermal capillaries (m/h)
V_d	=	Deposition velocity (m/h)
K_{p_b}	=	Permeability coefficient that describes the transport of a gas-phase chemical from the boundary layer a the skin surface (b) through the stratum corneum/viable epidermis composite to dermal capillaries (m/h)

$$DerFlux_{z1,c} = \frac{K_{p\_g} \times C_{g,z1c}}{CF} \tag{78}$$

$$CADD = \frac{\left(DerFlux_{z1,c} \times \text{FracTime}_{z1,c} + DerFlux_{z2,c} \times \text{FracTime}_{z2,c}\right) \times \frac{SA}{BW} \times ED_{cr} \times CF_1}{AT_{cr} \times CF_2}$$

$$ADR = \frac{\left(DerFlux_{z1,a} \times \text{FracTime}_{z1,a} + DerFlux_{z2,a} \times \text{FracTime}_{z2,a}\right) \times \frac{SA}{BW} \times ED_{ac} \times CF_1}{AT_{ac} \times CF_2}$$

Where:

$C_{g,z2c}$	=	Average chronic gas phase concentration
CF	=	Conversion factor (10000 cm²/m²)
$DerFlux_{z1,c}$	=	Chronic dermal flux
$\text{FracTime}_{z1,c}$	=	Fraction of time in Zone
$\frac{SA}{BW}$	=	Surface area to body weight ratio (cm²/kg)
ED_{cr}	=	Exposure duration, chronic (years)
CF_1	=	Conversion factor (24 hrs/day)
AT_{cr}	=	Averaging time, chronic (years)
CF_2	=	Conversion factor (1000 µg/mg)

The calculation can be incorporated into the spreadsheet analysis using parameters extracted from CEM, estimated using PARAMS, or from the literature search.

1.6 Consumer Exposure Results

All modeling results were exported into an Excel workbook for additional processing and summarizing. Outputs from the models used for consumer exposure were in units of mg/m^3. Health endpoints were provided in parts per million (ppm), therefore the U.S. EPA converted units from mg/m^3 to ppm by multiplying the concentration output by the molar volume (24.45) and dividing by the molecular weight of perchloroethylene (165.833 g/mol) using the following equation.

Concentration (ppm) = 24.45 X concentration (mg/m^3)/MW

All modeling inputs are provided in the *Draft Risk Evaluation for Perchloroethylene (PCE) Supplemental File: Consumer Exposure Assessment Model Input Parameters* (supplemental file #22), this file also contains the full dermal inputs, calculations and outputs for the consumer dry cleaned article COU. Model outputs for the inhalation and dermal consumer exposure are summarized (all consumer scenario iterations, final results) in the *Draft Risk Evaluation for Perchloroethylene (PCE) Supplemental File: Consumer Inhalation Exposure Risk Calculations* (supplemental file #18) and *Draft Risk Evaluation for Perchloroethylene (PCE) Supplemental File: Consumer Dermal Exposure Risk Calculations* (supplemental file #19).

2 Model Sensitivity Analysis

Model sensitivity analyses conducted on the models used for this evaluation enable users to identify what input parameters have a greater impact on the model results (either positive or negative). This information was used for this evaluation to help justify the approaches used and input parameters varied for the modeling.

2.1 CEM Sensitivity Analysis

The CEM developers conducted a detailed sensitivity analysis for CEM version 1.5, as described in Appendix C of the CEM User Guide.

In brief, the analysis was conducted on non-linear, continuous variables and categorical variables that were used in CEM models. A base run of different models using various product or article categories along with CEM defaults was used. Individual variables were modified, one at a time, and the resulting Chronic Average Daily Dose (CADD) and Acute Dose Rate (ADR) were then compared to the corresponding results for the base run. Two chemicals were used in the analysis: bis(2-ethylhexyl) phthalate was chosen for the SVOC Article model (emission model E6) and benzyl alcohol for other models. These chemicals were selected because bis(2-ethylhexyl) phthalate is a SVOC, better modeled by the Article model, and benzyl alcohol is a VOC, better modeled by other equations.

All model parameters were increased by 10% except those in the SVOC Article model (increased by 900% because a 10% change in model parameters resulted in very small differences). The measure of sensitivity for continuous variables was elasticity, defined as the ratio of percent change in each result to the corresponding percent change in model input. A positive elasticity means that an increase in the model parameter resulted in an increase in the model output whereas a negative elasticity had an associated decrease in the model output. For categorical variables such as receptor and room type, the percent difference in model outputs for different category pairs was used as the measure of sensitivity. The results are summarized below for inhalation vs. dermal exposure models and for categorical vs. continuous user-defined variables.

2.1.1 Exposure Models

For the first five inhalation models (E1-E5) a negative elasticity was observed when increasing the use environment, building size, air zone exchange rate, and interzone ventilation rate. All of these factors decrease the chemical concentration, either by increasing the volume or by replacing the indoor air with cleaner (outdoor) air. Increasing the weight fraction or amount of product used had a positive elasticity because this change increases the amount of chemical added to the air, resulting in higher exposure. Vapor pressure and molecular weight also tended to have positive elasticities.

For most inhalation models, the saturation concentration did not have a notable effect on the ADR or the CADD. Mass of product used and weight fraction both had a positive linear relationship with dose. All negative parameters had elasticities less than 0. 4, indicating that some terms (e.g., air exchange rates, building volume) mitigated the full effect of dilution. That is, even though the concentration is lowered, the effect of removal/dilution is not stronger than that of the chemical emission rate. Most models had an increase in dose with increasing duration of use. Increasing this parameter typically increases the peak concentration of the product, thus giving a higher overall exposure.

The results for the dermal model were different from the inhalation models, in that the elasticities for CADD and ADR were nearly the same. This outcome is consistent with the model structure, in that the chemical is placed on the skin so there is no time factor for a peak concentration to occur. The modeled exposure is based on the ability of a chemical to penetrate the skin layer once contact occurs. Dermal permeability had a near linear elasticity whereas log K_{OW} and molecular weight had zero elasticities.

2.1.2 User-defined Variables

These variables were separated into categorical vs. continuous. For categorical variables there were multiple parameters that affected other model inputs. For example, varying the room type changed the ventilation rates, volume size and the amount of time per day that a person spent in the room. Thus, each modeling result was calculated as the percent difference from the base run. For continuous variables, each modeling result was calculated as elasticity.

Among the categorical variables, both inhalation and dermal model results had a positive change when comparing an adult to a child and to a youth, with dermal having a smaller change between receptors than inhalation and the largest difference occurring between an adult and a child for both models. The time of day when the product was used and the duration of use occurred while the person was at home; thus, there was no effect on the ADR because the acute exposure period was too short to be affected by work schedule. Most rooms had a negative percent difference for inhalation, with the single exception of the bedroom where the receptor spent a large amount of time with a smaller volume than the living room. For dermal, the only room that resulted in a large percent difference was office/school, due to the fact that the person spent only ½ hour at that location when the stay-at-home activity pattern was selected. For inhalation, changing from a far field to a near field base resulted in a higher ADR and CADD, likely because the near field has a smaller volume than that of the total room.

There are three input parameters for the near-field, far-field option for CEM product inhalation models. To determine the sensitivity of model results to these inputs, CEM first was run in base scenario with the near-field option, after which separate runs were performed whereby the near-field volume was increased by 10%, the far-field volume was increased by 10%, and the air exchange rate was increased by 10%. For inhalation, both the air exchange rate and volume had negative elasticities, but the air exchange rate had a much higher elasticity (near one) than the volume (0.11).

3 Supplemental Information for Consumer Exposure

3.1 Systematic Review for Perchloroethylene for Consumer Exposure Data Evaluation Tables

See supplemental file: Draft Perchloroethylene Risk Evaluation Systematic Review Supplemental File: Data Quality Evaluation for Data Sources on Consumer and Environmental Exposure

Table 3- 1. Monitoring Data Extracted for Perchloroethylene for Indoor Air, Personal Breathing Zone, Surface Water, and Wastewater

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
Indoor Air (μg/m^3)											
US	Michigan (south-east)	*Commercial/Public* Office area of commercial buildings (n=4), including two art museums, a university building and a tire store/auto service. Stationary samples collected	2005-2008	5 (0.8)	0.002	ND to 39.7	8.02 (mean); 0.1 (median)	0.91	2214330	(Jia et al. 2010)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		from breathing height.									
US	Detroit, MI area	*Residential* Homes (n=126) with children with asthma	2009-2010	126 (0.91)	0.09	ND to 13.7	0.71 (mean); 0.26 (median)	--	2443355	(Chin et al. 2014)	High
US	California (statewide)	*Commercial/Public* Furniture/hardware stores (n=8)	2011-2013	58 (0.48)	0.32	0.32 to 22.2	5.6 (mean); NR (median)	--	2535652	(Chan et al. 2014)	High
US	California (statewide)	*Commercial/Public* Grocery stores (n=8)	2011-2013	76 (0.32)	0.32	0.32 to 5.9	1 (mean); NR (median)	--	2535652	(Chan et al. 2014)	High
US	California (statewide)	*Commercial/Public* Apparel stores (n=2)	2011-2013	20 (0.3)	0.32	0.32 to NR	0.2 (mean); NR (median)	--	2535652	(Chan et al. 2014)	High
US	Baltimore, MD	*Commercial/Public (Near Source: photocopy shop)* Personal samples from breathing zone. One from each of the three printing centers.	2000	4 (1)	NR	0.678 to 3.39	2.04 (mean); 1.36 (median)	4.75	1953674	(Stefaniak et al. 2000)	High
US	Baltimore, MD	*Commercial/Public (Near Source: photocopy shop)* Area samples from different locations within each of the three printing centers.	2000	17 (0.94)	NR	ND to 21.7	2.04 (mean); 1.36 (median)	--	1953674	(Stefaniak et al. 2000)	High
US	Elizabeth, NJ; Houston, TX; and Los Angeles, CA	*Residential* Non-smoking households (n=310)	1999-2001	539 (NR)	0.21	NR	1.85 (mean); 0.82 (median)	7.29	2128575	(Su et al. 2013)	Medium
US	CA (five regions)	*Commercial/Public* Commercial buildings (n= 37), 1 m from floor: Fleet	2011	40 (0.94)	0.22	ND to 118	NR (mean); NR (median); 0.18 (GM)	--	1062239	(Wu et al. 2011)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		service / Gas station convenience store, Dentist office / Healthcare facility, Grocery / Restaurant, Hair salon / Gym, Office Miscellaneous, Retail									
US	Southeast Michigan	*Residential* Homes (n = 15) sampled in various locations in the home (upstairs downstairs)	2005	15 (0.73)	0.07	NR to 4.4	0.6 (mean); NR (median)	--	1065558	(Batterman et al. 2007)	High
US	Southeast Michigan	*Residential* Garages of residences (n = 15)	2005	15 (0.33)	0.07	NR to 1.6	0.3 (mean); NR (median)	1.7	1065558	(Batterman et al. 2007)	High
US	Boston, MA	*Residential* Garage of residences	2004-2005	16 (0.81)	0.07	ND to NR	2.8 (mean); 0.3 (median)	3.4	1065844	(Dodson et al. 2008)	High
US	Boston, MA	*Residential* Apartment hallway of residences	2004-2005	10 (0.9)	0.07	ND to NR	1.9 (mean); 0.8 (median)	0.92	1065844	(Dodson et al. 2008)	High
US	Boston, MA	*Residential* Basement of residences	2004-2005	52 (0.98)	0.07	ND to NR	1.7 (mean); 0.5 (median)	3.1	1065844	(Dodson et al. 2008)	High
US	Boston, MA	*Residential* Interior room of residences	2004-2005	83 (0.92)	0.07	ND to NR	1.9 (mean); 0.6 (median)	0.2	1065844	(Dodson et al. 2008)	High
US	Los Angeles	*Residential* Homes (n=35) in inner-city neighborhood, sampled in the fall	2000	32 (1)	0.15	0.6 to 6.8	1.8 (mean); 1.3 (median)	1.9	1066049	(Sax et al. 2004)	High
US	Los Angeles, CA	*Residential* Homes (n=40) in	2000	40 (1)	0.15	0.7 to 11	2.3 (mean); 1.9 (median)	8.7	1066049	(Sax et al. 2004)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		inner-city neighborhood sampled in the winter									
US	New York, NY	*Residential* Homes (n=41) in inner-city neighborhood, sampled in the summer	1999	30 (0.78)	0.15	ND to 43	5.3 (mean); 2 (median)	13.1	1066049	(Sax et al. 2004)	High
US	New York, NY	*Residential* Homes (n=38) in inner-city neighborhood, sampled in the winter	1999	36 (1)	0.15	0.8 to 78	6.7 (mean); 3.5 (median)	1.2	1066049	(Sax et al. 2004)	High
US	Ann Arbor, Ypsilanti, and Dearborn Michigan	*Residential* Residences (n=159) in industrial, urban and suburban cities over two seasons	2004-2005	252 (0.99)	0.02	ND to 27.8	0.93 (mean); 0.39 (median)	--	1488206	(Jia et al. 2008a)	Medium
US	CA	*School* Early childhood education facilities (n=33) at sample height of 1 m.	2010-2011	33 (0.52)	NR	0.07 to 7.8	0.4 (mean); 0.1 (median); 0.1 (GM)	5.31	3453092	(Hoang et al. 2016)	High
US	Southern California	*Commercial/Public* Gene Autry Museum, sampled in various areas (an exhibit area, hallway near truck delivery door, and conservation room)	1989	600 (NR)	NR	0.20 to 5.97	NR (mean); NR (median)	235	28104	(Hisham and Grosjean 1991)	Medium
US	Southeast Chicago	*Residential* Urban homes (n=10) sampled over a 10-month	1994-1995	48 (1)	NR	0.54 to 13.1	2.61 (mean); 2.17 (median)	--	31210	(Van Winkle and Scheff 2001)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		period. Stationary samples were collected from the kitchen in the breathing zone.									
US	NR	*Commercial/Public* (Near Source: printmaking) Printmaking art studio at a university (n =1). Mechanically vented second-floor studio, with area samples collected near a cleaning station and in the middle of the studio during a printmaking session.	2002	18 (<1)	NR	ND to NR	0.4 (mean); 0.18 (median)	1.2	49414	(Ryan et al. 2002)	High
US	NR	*Commercial/Public* Non-art related floor at a university, three floors above a printmaking floor with separate ventilation (n =1). Area samples collected from hallway.	2002	18 (<1)	NR	ND to NR	0.4 (mean); 0.18 (median)	8.1	49414	(Ryan et al. 2002)	High
US	Washington, DC area	*Coin Operated Laundry with Dry Cleaning Machines* Laundry facility (Site A), sampled at 6 to 7 ft above floor	1980	18 (1)	NR	617 to 1357	882 (mean); NR (median)	--	58127	(Howie 1981)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		at three locations. Use of dry cleaning machine low, but dry-cleaned clothes stored on site. Large facility. Good airflow.									
US	Washington, DC area	*Coin Operated Laundry with Dry Cleaning Machines* Laundry facility (Site C), sampled at 6 to 7 ft above floor at three locations. Eight attendant operated dry cleaning machines on-site. Good air circulation because of floor plan, front door open at all times.	1980	18 (1)	NR	1696 to 18318	8820 (mean); NR (median)	--	58127	(Howie 1981)	High
US	Washington, DC area	*Coin Operated Laundry with Dry Cleaning Machines* Laundry facility (Site B), sampled at 6 to 7 ft above floor at three locations. 2 attendant operated dry-cleaning machines on-site. Ventilation and circulation good, front door open regularly.	1980	18 (1)	NR	509 to 4749	2171 (mean); NR (median)	--	58127	(Howie 1981),	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
US	Washington, DC area	*Coin Operated Laundry with Dry Cleaning Machines* Laundry facility (Site D), sampled at 6 to 7 ft above floor at three locations. Four customer-operated dry-cleaning machines on-site. Limited air circulation, but front door open at all times.	1980	18 (1)	NR	3148 to 4206	39351 (mean); NR (median)	--	58127	(Howie 1981)	High
US	Washington, DC area	*Coin Operated Laundry with Dry Cleaning Machines* Laundry facility (Site E), sampled at 6 to 7 ft above floor at three locations. Four attendant-operated dry-cleaning machines on-site. Air-conditioned site with re-circulated indoor air.	1980	18 (1)	NR	12891 to 94985	58348 (mean); NR (median)	--	58127	(Howie 1981)	High
US	Washington, DC area	*Coin Operated Laundry with Dry Cleaning Machines* Laundry facility (Site F), sampled at 6 to 7 ft above floor at three locations. Eight attendant-operated dry cleaning machines	1980	18 (1)	NR	2239 to 21032	8820 (mean); NR (median)	--	58127	(Howie 1981)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		on-site. Limited air circulation because of floor plan; front door open at all times.									
US	Denver, CO	*Residential* Homes, occupied (n=9)	1994	9 (0.89)	0.14	ND to 1.99	0.66 (mean); 0.33 (median)	2.63	78782	(Lindstrom et al. 1995)	Medium
US	Minneapolis, MN	*School* Indoors in five randomly selected classrooms in each school, during the spring.	2000	113 (0.86)	NR	NR	NR (mean); 0.3 (median)	--	632310	(Adgate et al. 2004)	Medium
US	Minneapolis, MN	*School* Indoors in five randomly selected classrooms in each school, during the winter.	2000	113 (0.96)	NR	NR	NR (mean); 0.3 (median)	--	632310	(Adgate et al. 2004)	Medium
US	Minneapolis, MN	*Residential* Indoors in the child's primary residence, during the spring.	2000	113 (0.95)	NR	NR	NR (mean); 0.4 (median)	--	632310	(Adgate et al. 2004)	Medium
US	Minneapolis, MN	*Residential* Indoors in the child's primary residence, during the winter.	2000	113 (0.98)	NR	NR	NR (mean); 0.5 (median)	--	632310	(Adgate et al. 2004)	Medium
MX	Mexico City Metropolitan Area	*Residential* Homes	1998-1999	30 (1)	NR	NR to 43.6	5.5 (mean); 3 (median); 3.6 (GM)	--	56224	(Serrano-Trespalacios et al. 2004)	High
CA	NR	*Residential* Homes (n=12), main floor	1986	12 (1)	NR	1 to 171	28.1 (mean); NR (median)	--	27974	(Chan et al. 1990)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
CA	NR	*Residential* Homes (n=6), main floor	1987	6 (1)	NR	2 to 18	6.2 (mean); NR (median)	--	27974	(Chan et al. 1990)	Medium
IT	NR	*Residential* Control Homes - 25 private homes with individuals not occupationally exposed, but within the same district near the dry-cleaners' homes.	1994	25 (1)	1	ND to 16	3 (mean); 2 (median); 2 (GM)	--	21778	(Aggazzotti et al. 1994a)	Medium
IT	Modena	*Residential* Households (n=29) with no association with dry cleaning establishments.	1992-1993	58 (NR)	1	1 to 56	NR (mean); 6 (median); 0.006 (GM)	3	74875	(Aggazzotti et al. 1994b)	High
NL	Ede and Rotterdam	*Residential* Suburban homes built post WWII, Inner-city homes built prior to WWII, and newer homes < 6 years old. Samples collected in living room.	1981-1982	319 (0.3)	2	ND to 205	NR (mean); 1 (median)	--	22186	(Lebret et al. 1986)	Medium
FI	NR	*Residential* Normal houses (not "sick houses"). 50 "Normal houses" in this study.	1995	50 (NR)	NR	ND to 5.65	0.46 (mean); 0.3 (median)	11	76241	(Kostiainen 1995)	Medium
FI	NR	*Residential* "Sick houses" - houses in which people complained	1995	7 (NR)	NR	0.19 to 29.8	4.86 (mean); 0.73 (median)	0.66	76241	(Kostiainen 1995)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		about the odor or they had symptoms, which resembled WHO's Sick Building Syndrome (headache, nausea, irritation of the eyes, mucous membranes, and the respiratory system, drowsiness, fatigue, and general malaise. 38 "sick houses" in this study.									
SG	nation-wide	*School* Child-care centers (n=104), sampled from middle of the classroom near the breathing zone of children (approximately 0.5–0.7 m)	2007	84 (0.72)	0.6	ND to 8.5	NR (mean); 0.3 (median)	--	632758	(Zuraimi and Tham 2008)	High
DE	Hamburg area	*Vehicle (Near Source: dry-cleaning)* Dry-cleaned down jacket placed into a car.	1990	3 (1)	NR	9300 to 24800	NR (mean); NR (median)	--	713690	(Gulyas and Hemmerling 1990)	Medium
SA	Kuwait	*Residential* Houses (n=20), sampled from living room	1998	226 (0.93)	0.26	ND to NR	NR (mean); NR (median)	--	1744157	(Bouhamra and Elkilani 1999)	Medium
FR	nation-wide	*Residential* Main dwellings(n=490),	2003-2005	490 (0.84)	0.4	ND to 72.1	NR (mean); 1.3 (median)	--	733119	(Billionnet et al. 2011)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		samples collected from bedroom.									
FR	Paris area	*Residential* Homes (n=196) of the PARIS birth cohort with sampling in the infant bedroom at 1, 6, 9, and 12 months old.. Annual levels averaged from hot and cold seasonal levels.	2003-2007	177 (1)	0.4	0.6 to 124.2	NR (mean); 2.3 (median); 2.8 (GM)	--	2128839	(Roda et al. 2013)	Medium
FR	Paris area	*Residential* Homes (n=196) of the PARIS birth cohort with sampling in the infant bedroom at 1, 6, 9, and 12 months old. Hot season levels.	2003-2008	177 (NR)	0.4	0.4 to 245	NR (mean); 2.1 (median); 2.4 (GM)	--	2128839	(Roda et al. 2013)	Medium
FR	Paris area	*Residential* Homes (n=196) of the PARIS birth cohort with sampling in the infant bedroom at 1, 6, 9, and 12 months old.. Cold season levels.	2003-2009	177 (1)	0.4	0.6 to 59.2	NR (mean); 2.4 (median); 2.8 (GM)	15.8	2128839	(Roda et al. 2013)	Medium
FR	nation-wide	*Residential* Dwellings with clothes that have been dry cleaned in the previous 4 weeks. (n=94)	2003-2005	98 (NR)	NR	NR	5.3 (mean); NR (median); 2.5 (GM)	10.6	2855333	(Brown et al. 2015)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
FR	nation-wide	*Residential* Dwellings without clothes that have been dry cleaned in the previous 4 weeks. (n=447)	2003-2005	456 (NR)	NR	NR	3.7 (mean); NR (median); 1.1 (GM)	32.6	2855333	(Brown et al. 2015)	Medium
RS	Novi Sad	*Commercial/Public (Near Source: photocopy shop)* Photocopy shop (n=1) with a desktop computer, laptop computer, 2 copiers, and a printer	2015	225 (0.64)	6.78	6.78 to 96342	4953 (mean); 6.78 (median)	--	3371701	(Kiurski et al. 2016)	Medium
SG	NR	*Commercial/Public* Office building (n=1), 6 months old with normal occupancy and steady state ventilation system sampled in the middle	2004	8 (NR)	NR	NR	2321 (mean); NR (median)	78.5	3393192	(Tham et al. 2004)	Low
DE	Essen and Borken	*Residential* Residential homes, collected in room where inhabitants spent the most amount of time at a height of 1.5 to 2 meters.	1996	229 (1)	NR	0.03 to 7.33	2.21 (mean); NR (median)	--	3561656	(Begerow et al. 1996)	High
DE	Leipzig	*Residential* Homes (n=85), sampled from bedroom of infants for 4 weeks after birth.	1997-1999	85 (NR)	NR	NR	NR (mean); 1.8 (median)	--	34460	(Lehmann et al. 2002)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
EU	Sweden, Finland, Estonia, Lithuania, Belgium, UK, France, Austria, Germany, Poland, Slovakia, Czech Republic, Hungary, Romania, Bulgaria, Serbia, Bosnia and Herzegovina, Italy, Portugal, Malta, Greece, Cyprus, and Albania	*School* Kindergartens (n=25).	2014	25 (NR)	NR	ND to 6	1 (mean); 0.18 (median)	2	4440449	(Ec 2014)	High
EU	Sweden, Finland, Estonia, Lithuania, Belgium, UK, France, Austria, Germany, Poland, Slovakia, Czech Republic, Hungary, Romania, Bulgaria, Serbia, Bosnia and Herzegovin a, Italy, Portugal, Malta, Greece Cyprus, and Albania	*School* Primary schools (n=300).	2014	300 (NR)	NR	ND to 81	1 (mean); 0.18 (median)	2	4440449	(Ec 2014)	High

EU	Sweden, Finland, Estonia Lithuania, Belgium, UK,	*School* Primary schools where teachers	2014	106 (NR)	NR	ND to 31	1 (mean); 0.18 (median)	--	4440449	(Ec 2014)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
	France, Austria, Germany, Poland, Slovakia, Czech Republic, Hungary, Romania, Bulgaria, Serbia, Bosnia and Herzegovina, Italy, Portugal, Malta, Greece, Cyprus, and Albania	participated (n=106).									
CN	NR	*Commercial/Public* Non-office premises (n=10) including one library, one social services center, two customer services centers, two shopping malls, two recreational building units, one reception area and one training center under renovation. 1.1 m above the floor level.	1998-2000	10 (0.6)	0.3	ND to 10.9	3 (mean); 2.2 (median); 1.4 (GM)	9.2	824555	(Chao and Chan 2001)	Medium
CN	NR	*Commercial/Public* Office buildings (n=10), 1.1 m above the floor	1998-2000	10 (0.6)	0.3	ND to 30.5	5.2 (mean); 1.8 (median); 1.9 (GM)	--	824555	(Chao and Chan 2001)	Medium
CN	Shanghai	*Residential* Eight residences that had been renovated within the previous year.	2015	8 (NR)	NR	NR	2.38 (mean); 0.72 (median)	0.15	3453725	(Dai et al. 2017)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		Three sampling sites were used in each participating residence (the living room bedroom, and study).									
JP	Shimizu, Shizuoka Prefecture	*Residential* Single-family houses (n=25) in industrial harbor area, sampled in the main living area	2001	25 (1)	NR	NR	NR (mean); NR (median); 0.16 (GM)	--	632484	(Ohura et al. 2006)	High
JP	Shimizu, Shizuoka Prefecture	*Residential* Single-family houses (n=21) in industrial harbor area, sampled in the main living area	2001	21 (1)	NR	NR	NR (mean); NR (median); 0.16 (GM)	0.33	632484	(Ohura et al. 2006)	High
JP	Katsushika Ward, Tokyo	*Residential* 30 houses' bathrooms, sampled for 4 consecutive 24 hour periods. n=119	1995	119 (1)	NR	0.363 to 22.5	2.56 (mean); NR (median); 1.83 (GM)	--	3545469	(Amagai et al. 1999)	Medium
JP	Katsushika Ward, Tokyo	*Residential* 13 houses' living rooms, sampled for 4 consecutive 24 hour periods. n=52	1995	52 (1)	NR	0.294 to 8.13	1.42 (mean); NR (median); 0.986 (GM)	--	3545469	(Amagai et al. 1999)	Medium
JP	Katsushika Ward, Tokyo	*Residential* 13 houses' kitchens sampled for 4 consecutive 24 hour periods. n=52	1995	52 (1)	NR	0.295 to 8.25	1.17 (mean); NR (median); 0.829 (GM)	--	3545469	(Amagai et al. 1999)	Medium
JP	Katsushika Ward, Tokyo	*Residential* 13 houses' bedrooms, sampled	1995	52 (1)	NR	0.215 to 10.6	1.64 (mean); NR (median); 0.998 (GM)	--	3545469	(Amagai et al. 1999)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		for 4 consecutive 24 hour periods. n=52									
JP	Katsushika Ward, Tokyo	*Residential* 13 houses' bathrooms, sampled for 4 consecutive 24 hour periods. n=52	1995	52 (1)	NR	0.172 to 5.36	1.06 (mean); NR (median); 0.774 (GM)	--	3545469	(Amagai et al. 1999)	Medium
JP	Katsushika Ward, Tokyo	*Residential* 30 houses' living rooms, sampled for 4 consecutive 24 hour periods. n=238	1995	238 (1)	NR	0.292 to 57	3.69 (mean); NR (median); 2.36 (GM)	--	3545469	(Amagai et al. 1999)	Medium
JP	Katsushika Ward, Tokyo	*Residential* 30 houses' kitchens sampled for 4 consecutive 24 hour periods. n=119	1995	119 (1)	NR	0.339 to 30.8	3.03 (mean); NR (median); 2.02 (GM)	--	3545469	(Amagai et al. 1999)	Medium
JP	Katsushika Ward, Tokyo	*Residential* 30 houses' bedrooms, sampled for 4 consecutive 24 hour periods. n=238	1995	238 (1)	NR	0.358 to 71	4.24 (mean); NR (median); 2.42 (GM)	--	3545469	(Amagai et al. 1999)	Medium
Personal Breathing Zone (μg/m^3)											
US	IL, IN, OH, MI MN, WI (Great Lakes Region)	*Residential* Non-institutionalized persons residing in households in six states	1995-1997	386 (0.61)	NR	ND to NR	31.9 (mean); 1.98 (median)	--	14003	(Clayton et al. 1999)	High
US	Columbus, OH	*Residential* Non-smoking women (n=24) with non-smoking husbands	1991	24 (NR)	NR	ND to 5.13	1.24 (mean); 0.7 (median)	1.46	22045	(Heavner et al. 1995)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
US	Columbus, OH	*Residential* Non-smoking (n=25) women with smoking husbands	1991	25 (NR)	NR	ND to 3.78	0.89 (mean); 0.68 (median)	0.96	22045	(Heavner et al. 1995)	Medium
US	NR	*Commercial/Public (Near Source: printmaking)* 12 students and 1 faculty member in university art (printmaking) studio. Mechanically ventilated second-floor.	2002	90 (NR)	NR	ND to NR	0.7 (mean); 0.5 (median)	2.3	49414	(Ryan et al. 2002)	High
US	NR	*General* Personal VOC exposures of 851 adults, who were part of the NHANES study (no additional exclusion criteria), sampled via badge-type passive exposure monitors for 48–72 h. Additionally, participants were administered a short questionnaire regarding the length of time they wore their badge and 30 other questions on factors potentially related to VOC exposures, e.g., contact with dry	1999-2000	665 (0.69)	0.42	ND to 659	5.2 (mean); 0.7 (median); 1 (GM)	31.2	484177	(Jia et al. 2008b)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		cleaning, tobacco smoke and gasoline vapor over the past several days.									
US	Minneapolis, MN	*Residential* In personal breathing zones, during the winter.	2000	113 (1)	NR	NR	0.4 (median)	--	632310	(Adgate et al. 2004)	Medium
US	Minneapolis, MN	*Residential* In personal breathing zones, during the spring.	2000	113 (0.97)	NR	NR	0.4 (median)	--	632310	(Adgate et al. 2004)	Medium
US	Minneapolis-St. Paul, MN	*General* Adults, non-smoking (n=70) living in three neighborhoods: (inner-city/economically disadvantaged, blue-collar/near manufacturing plants, and affluent)	1999	333 (1)	NR	NR	27.8 (mean); 0.9 (median)	--	730121	(Sexton et al. 2007)	High
US	Elizabeth, NJ; Houston, TX; and Los Angeles, CA	*General* Adults (n=309) and children (n=118) from 310 non-smoking households.	1999-2001	544 (NR)	0.21	NR	7.17 (mean); 0.89 (median)	112.35	2128575	(Su et al. 2013)	Medium
US	Greater Boston Metropolitan Area	*Commercial/Public* Drug Stores (n=8)	2003	7 (NR)	0.22	0.45 to 2.16	0.86 (GM)	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Furniture Stores (n=11)	2003	6 (NR)	0.22	0.49 to 6.35	1.34 (GM)	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Grocery Stores (n=16)	2003	12 (NR)	0.22	0.42 to 4.83	0.95 (GM)	--	2442846	(Loh et al. 2006)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
US	Greater Boston Metropolitan Area	*Commercial/Public* Hardware Stores (n=32)	2003-2004	23 (NR)	0.22	0.22 to 21.1	1.79 (GM)	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Housewares Stores (n=16)	2003	7 (NR)	0.22	1.27 to 7.41	1.48 (GM)	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Multipurpose Stores (n= 24)	2003-2005	43 (NR)	0.22	0.52 to 43.8	1.18 (GM)	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Sporting Goods Stores (n=14)	2003	7 (NR)	0.22	1.24 to 11.6	2.96 (GM)	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Dining Stores (n=20)	2004	20 (NR)	0.22	0.24 to 83.4	NR	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Transportation Stores (n=5)	2003-2004	21 (NR)	0.22	0.32 to 5.17	0.78 (GM)	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Department Stores (n=10)	2004	5 (NR)	0.22	1.27 to 4.89	2.04 (GM)	--	2442846	(Loh et al. 2006)	High
US	Greater Boston Metropolitan Area	*Commercial/Public* Electronics Stores (n=9)	2004	7 (NR)	0.22	ND to 8.49	0.47 (GM)	--	2442846	(Loh et al. 2006)	High
US	CA and NJ	*General* Adults conducting normal daily activities	1981-1984	772 (NR)	0	NR	5.6 to 45 (mean)	--	23081	(Wallace 1986)	High
MX	Mexico City Metropolitan Area	*General* General - different activity patterns: Three individuals from each family were selected to represent different activity patterns: a long commuter, another engaged in	1998-1999	90 (1)	NR	NR to 84.4	5.9 (mean); 3.7 (median); 4.1 (GM)	9.9	56224	(Serrano-Trespalacios et al. 2004)	Low

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		some activities outside the home during the day but with no routine long commutes, and one staying at or near the home most of the day									
Indoor Air, Personal Breathing Zones, and Breath from Exposure Studies with Dry-Cleaned Textiles (µg/m3)											
US	Bayonne and Elizabeth, NJ	*Residential* Indoor air of living rooms and bedrooms of nine homes with two to ten sets of dry-cleaned clothes were brought into the homes.	NR	18	NR	NR to 297	NR	--	28307	(Thomas et al. 1991)	High
US	Bayonne and Elizabeth, NJ	*Residential* Personal air two to ten sets of dry-cleaned clothes were brought into the homes.	NR	7	1	NR to 303	NR	--	28307	(Thomas et al. 1991)	High
US	Bayonne and Elizabeth, NJ	*Residential* Exhaled breath, two to ten sets of dry-cleaned clothes were brought into the homes.	NR	7	1	NR to 303	NR	--	28307	(Thomas et al. 1991)	High
US	NR	*Residential* Single story residential house with dry-cleaning placed in closet. **Samples collected from the closet.**	NR	NR	1	NR	100-2,900 (daily avg)	--	27401	(Tichenor et al. 1990)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
US	NR	*Residential* Single story residential house with dry-cleaning placed in closet. **Samples collected from the bedroom**.	NR	NR	1	NR	20-195 (daily avg)	--	27401	(Tichenor et al. 1990)	High
US	NR	*Residential* Single story residential house with dry-cleaning placed in closet. **Samples collected from the den.**	NR	NR	1	NR	10-80 (daily avg)	--	27401	(Tichenor et al. 1990)	High
US	Washington, DC	*Residential* In late summer; Private home in rural residential area. Samples collected over 7 days after placing dry-cleaned clothing in the house.	1980	7(1)	NR	42.0 to 692	NR	--	58127	(Howie 1981)	High
US	NR	*Automobile* Modeled air concentration in vehicle with dry-cleaned jacket.	NR	NR	NR	NR to 2,300	NR	--	85812	(Park et al. 1998)	High
DE	NR	*Automobile* Car with a dry-cleaned down jacket placed in the car.	1990	3(1)	NR	9,300 to 24,800	NR	--	713690	(Gulyas and Hemmerling 1990)	Medium
CN	Hong Kong	*Residential* Home (Site A) with dry cleaned clothes in closet of urban	1996	28 (1)	NR	4.6 to 76	NR	--	3559311	(Chao et al. 1999)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		5th floor apartment bedroom.									
CN	Hong Kong	*Residential* Home (Site B) with dry cleaned clothes in closet of suburban 2nd floor apartment bedroom.	1996	28 (1)	NR	21 to 494	NR	--	3559311	(Chao et al. 1999)	Medium
CN	Hong Kong	*Residential* Home (Site C) with dry cleaned clothes in closet of urban 10th floor apartment bedroom.	1996	28 (1)	NR	0.93 to 100	NR	--	3559311	(Chao et al. 1999)	Medium
JP	NR	*Residential* Homes in Japan, dry cleaned clothes sampled in chest of drawers.	NR	9 (1)	NR	2.9 to 326.6	NR	--	3563210	(Kawauchi and Nishiyama 1989)	Medium
JP	NR	*Residential* Homes in Japan, dry cleaned clothes sampled in same room as chest of drawers.	NR	6 (1)	NR	1.3 to 7.4	NR	--	3563210	(Kawauchi and Nishiyama 1989)	Medium
Surface Water (µg/L)											
US	Anchorage, AK	Background Chester Creek (6 urban sampling sites)	1998-2001	11 (0)	0.2	All ND	ND	NR	3975042	(USGS 2006)	Medium
US	Nation-wide	*Background* Surface water for drinking water sources (rivers and reservoirs)	1999-2000	375 (0.008)	0.2	ND to 5.5	NR	NR	3975046	(USGS 2003)	Medium
US	Nation-wide	Surface water for drinking water sources (rivers and reservoirs)	1999-2000	375 (0.0027)	0.2	ND to 2.6	NR	NR	3975046	(USGS 2003)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
US to CL	NR	*Background* Eastern Pacific Ocean (California US to Valparaiso, Chile)	1979-1981	30 (0.90)	0.0001	ND to 0.0028	0.7 (mean); 0.0004 (median)	0.0007	29192	(Singh et al. 1983)	Medium
US to CL	NR	Eastern Pacific Ocean (California US to Valparaiso, Chile)	1979-1981	30 (0.93)	0.0004	ND to 0.008	0.0031 (mean)	0.0032	29192	(Singh et al. 1983)	Medium
BR	NR	*Background* Santo Antonio da Patrulha, Tres Coroas, and Parobe in the Sinos River Basin; River samples collected from seven points on the three main rivers of the Sinos River Basin	2012-2013	60 (0.083)	NR	ND to 0.8	0.03 (mean)	NR	3489827	(Bianchi et al. 2017)	Medium
BR	NR	Santo Antonio da Patrulha, Tres Coroas, and Parobe in the Sinos River Basin; River samples collected from seven points on the three main rivers of the Sinos River Basin	2012-2013	60 (0.72)	NR	ND to 0.0588	0.0019 (mean)	NR	3489827	(Bianchi et al. 2017)	Medium
CN	NR	*Background* Yellow Sea and East China Sea (53 stations)	2011	53 (1.0)	NR	0.00022 to 0.0051	0.0019 (mean)	NR	2128010	(He et al. 2013a)	High
CN	NR	*Background* Daliao River (n=20 sites), heavily industrialized	2011	20 (0.1)	NR	NR to 0.11	0.016 (mean)	NR	3488897	(Ma et al. 2014)	High
CN	NR	*Background*	2010	41 (1)	NR	0.000065 to 0.0015	0.0004 (mean)	NR	1940132	(He et al. 2013b)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		East China Sea; Seawater (41 stations)									
ES	North-Western area	*Background* River Duero (11 stations)	2007	11 (NR)	NR	NR to 0.09	0.01 (mean)	NR	3501965	(Blanco and Bécares 2010)	Medium
GB	NR	*Background* Irish Sea; Liverpool Bay and River Mersey (18 stations)	2006	18 (NR)	0.000025	ND to 0.0455	NR	NR	2277377	(Bravo-Linares et al. 2007)	Medium
RU	NR	*Background* Kalmykian Steppe; Rivers, springs, lakes, salt lakes (n=23); polluted and remote areas	1999-2003	23 (0.83)	0.005	ND to 310	24.6 (mean)	81.8	104106	(Weissflog et al. 2004)	Medium
PT	Nation-wide	*Background* sea, estuarine, river water and industrial effluents (46 water sample locations)	1999-2000	644 (0.20)	0.4	ND to 13	NR	NR	659075	(Martinez et al. 2002)	Medium
BE	NR	*Background* Southern North Sea; Southern Bight, Belgian Continental Shel, the mouth of the Scheldt estuary and the Channel (10 stations total)	1998-2000	47 (NR)	NR	NR to 0.28	0.023 (mean); 0.0015 (median)	NR	660096	(Huybrechts et al. 2005)	High
EU	NR	*Background* Estuaries of the Scheldt (n=2), Thames, Loire, Rhine	1997-1999	73 (NR)	0.000099	ND to 1.2	NR	NR	3242836	(Christof et al. 2002)	High
EU	NR	Estuaries of the Scheldt (n=2), Thames, Loire, Rhine	1997-1999	73 (1)	NR	0.0003 to 4.98	NR	NR	3242836	(Christof et al. 2002)	High
GR	Northern Greece	*Background*	1996-1998	104 (NR)	0.02	ND to 0.19	NR	NR	1024859	(Kostopoulou et al. 2000)	High

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		Rivers (n=4) and lakes (n=5). Rivers sampled at the estuary and near the frontier. Lakes - Vegoritida, Volvi, Vistonida, Large Prespa and Small Prespa. Rivers - Evros, Nestos, Strimonas, and Axios									
JP	Osaka	*Background* Rivers in heavily industrialized area (n=10 stations). Wastewater treatments upstream from the sampling sites.	1995-1997	106 (0.85)	NR	0.47 to 86.2	4.83 (mean); 2.44 (median)	9.32	2310570	(Yamamoto et al. 2001)	Medium
FR	Paris	*Background* River samples (raw) collected from the River Seine (n=14 stations), River Marne (n=1 station) and River Oise (n=1 station). Wastewater treatment plants are located on the river.	1994-1995	43 (1)	NR	0.068 to 1.037	0.31 (mean); 0.196 (median)	0.248	3587944	(Duclos et al. 2000)	Medium
FR	Paris	River samples (raw) collected from the River Seine (n=14 stations), River Marne (n=1 station) and River Oise (n=1 station). Wastewater	1994-1995	43 (1)	NR	0.016 to 4.92	1.004 (mean); 0.473 (median)	1.218	3587944	(Duclos et al. 2000)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
		treatment plants are located on the river.									
JP	Osaka	Rivers and estuaries (30 sites) in industrialized city	1993-1995	136 (NR)	NR	NR to 134	1.7 (median)	NR	645789	(Yamamoto et al. 1997)	High
BE	NR	*Background* Southern North Sea and Scheldt Estuary; Seven sites in the southern North Sea and Scheldt Estuary.	1994-1995	38 (NR)	NR	NR	0.00268 (median)	NR	644857	(Dewulf et al. 1998)	High
EU	NR	*Background* Mersey Estuary; Freshwater input collected from the Howley Weir.	1987-1989	5 (NR)	NR	NR	0.6 (mean); 0.6 (median)	NR	2802879	(Rogers et al. 1992)	Medium
GR	Thermaikos and Kavala, Northern Greece	*Background* Seawater collected from Thermaikos Gulf (6 stations; near large city and industrial area) and Kavala Gulf stations (4 stations; near small city and off-shore oil-wells).	1981-1982	10 (1)	NR	0.00027 to 0.003	0.00131 (mean); 0.00116 (median)	0.00099	4149731	(Fytianos et al. 1985)	Low
CH	Background	*Background* River Aare; River samples collected at River Aare.	1980-1981	12 (NR)	NR	NR	0.24 (mean)	0.12	3797825	(Schwarzenbach et al. 1983)	Medium
CH	Background	*Background* River Glatt; River samples collected at River Glatt.	1979-1980	16 (NR)	NR	NR	0.6 (mean)	0.70	3797825	(Schwarzenbach et al. 1983)	Medium
GB	NR	*Background* Estuaries, docks, channels, bays, and inshore (n=48)	1992	48 (0.44)	NR	0.01 to 0.274	0.04491 (mean); 0.0125 (median)	0.0645	2803418	(Dawes and Waldock 1994)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
SE	Stenungsund area	*Background* Seawater (n=13 stations), sampled on two occasions (depths of 1-10 m) in area of petrochemical centre	1988	52 (NR)	NR	NR	0.0025 (mean)	NR	658636	(Abrahamsson et al. 1989)	Medium
GB	NR	*Background and Near Facility (Ship Tanker Cleaning Operations)* North Sea; North Sea: 32 sampling stations in the Thames, Humber, Tees, Forth, and Felixstowe (0 to 20 miles from shore) and the Central North Sea (distance from shore not provided). Tank cleaning operations at North Sea ports.	1986	32 (0.47)	0.002	ND to 0.16	15 (mean); 0.002 (median)	0.037	4149734	(Hurford et al. 1989)	Medium
IT	Emilia-Romagna region	*Background* Canal (n=1) which receives wastewater.	1984	6 (0.574)	NR	18 to 168	136 (mean)	NR	4149721	(Aggazzotti and Predieri 1986)	Low
AQ	NR	*Background* Northern Victoria Land; Five lakes (Carezza Lake, Edmonson Point Lakes, Tarn Flat Lake, Inexpressible Island Lake and Gondwana Lake)	2011-2012	6 (1)	NR	0.0056 to 0.0166	0.0097 (mean)	0.0038	2800175	(Insogna et al. 2014)	High
AQ	NR	*Background* Ross Sea	1997-1998	48 (NR)	NR	0.0002 to 0.071	0.02 (mean); 0.0056 (median)	0.023	2189687	(Zoccolillo et al. 2004)	Medium

Country	State/City/Region	Site	Year	No. of Samples (Det. Freq.)	Detection Level	Concentration			Reference (HERO ID)		
						Range	Central Tendency	Standard Deviation	HERO	Citation	Data Eval. Score
AQ	NR	*Background* Lakes at Tarn Flat and Edmonson Point; Two freshwater lakes	1998	4 (NR)	NR	0.0023 to 0.0041	0.0032 (mean); 0.0031 (median)	0.0007	2189687	(Zoccolillo et al. 2004)	Medium
Wastewater (µg/L)											
KR	Nation-wide	*Near Facility (industrial WWTPs)* Influent/Effluent	2012	81 (NR)	1	1 to 23	1 (median)	--	3580141	(Lee et al. 2015)	Medium
KR	Nation-wide	*Near Facility (industrial WWTPs)* Effluent	2012	81 (0)	1	ND	--	--	3580141	(Lee et al. 2015)	Medium
Biota (µg/kg)											
BE	Nation-wide	*Background* Eel, skin	2003	20 (0.5)	0.1	0.1 to 89	13.4 (mean); 0.78 (median)	NR	1066543	(Roose et al. 2003)	Medium

Study Info: The information provided includes the HERO ID and citation; country and year samples collected; number of samples and detection frequency.

Abbreviations: If a value was applicable, it is shown in this table as "—"; ND = not detected at the reported detection limit; GM = geometric mean; NR = not reported.

The following abbreviations are for countries/continents: AQ = Antarctica, BE = Belgium, BR = Brazil, CA = Canada, CH = Switzerland, CL = Chile, CN = China, DE = Germany, ES = Spain, EU = Europe, FI = Finland, FR = France, GB = Great Britain, GR = Greece, IT = Italy, JP = Japan, KR = Korea, MX = Mexico, NL = Netherlands, PT = Portugal, RS = Serbia, RU = Russia, SA = Saudi Arabia, SE = Sweden, SG = Singapore, US = United States.

Parameters: All statistics are shown as reported in the study. All minimum values determined to be less than the detection limit are shown in this table as "ND". If a maximum value was not provided, the highest percentile available is shown (as indicated in parentheses); if a minimum value was not provided, the lowest percentile available is shown (as indicated in parentheses).

3.2 Biomonitoring Data

Systematic review identified blood biomonitoring measurements from multiple sources. The most comprehensive source is the National Health and Nutrition Examination Survey (NHANES) conducted by CDC's National Center for Health Statistics (NCHS). The survey is "a complex, stratified, multistage, probability-cluster design survey" designed to collect data on the health and nutrition of a representative sample of the US population. NHANES measured perchloroethylene in whole blood of males and females ages 12+ years. In the Fourth Report on Human Exposure to Environmental Chemicals (CDC, 2017), statistics were reported for the 50th, 75th, 90th, and 95th percentiles for 2-year cycles starting in 2001 through 2016. Sample sizes ranged from 978 to 3,302. The concentrations in all samples were less than the limit of detection (0.048 ng/mL) at the 50th percentile for all years. At the 95th percentile, concentrations ranged from 0.075 in 2015-2016) to 0.190 ng/mL (in 2001-2002). Another source (Sexton et. al., 2005), measured concentrations of perchloroethylene in whole blood from 150 children from two poor, minority neighborhoods in Minneapolis, Minnesota in four periods during 2000-2001. These samples were collected as part of the School Health Initiative: Environment, Learning, Disease (SHIELD) study. perchloroethylene was detected in 37 to 63% of the samples, with concentrations ranging from 0.02-0.03 ng/mL (10th percentile) to 0.19-0.82 ng/mL (99th percentile). The limit of detection was 0.022 ng/mL. The SHIELD study also collected 2-day, integrated personal air samples. Blood samples were also collected as part of the National Human Exposure Assessment Survey (NHEXAS) Phase I conducted by EPA (Clayton et. al., 1999). Samples were collected from 147 people in six states (IL, IN, OH, MI, MN, and WI) in 1995-1997. perchloroethylene was detected in 37% of the samples, with a mean of 0.21 ng/mL, a 50th percentile of 0.05 ng/mL, and a 90th percentile of 0.16 ng/mL. NHEXAS Phase I also collected indoor air and personal air samples. perchloroethylene concentrations in blood were similar between the NHANES, SHIELD, and NHEXAS surveys conducted between 1995 and 2016.

In addition to blood, NHANES also collected urine spot samples. The perchloroethylene metabolite N-Acetyl-S-(trichlorovinyl)-L-cysteine was measured in males and females ages 6+ years in survey years 2005-2006 (n=3,349), 2011-2012 (n=2,464-2,466), and 2013-2104 (n=2,618-2,619). The concentrations in all samples were less than the limit of detection (3.0 µg/L).

Breath samples were also collected as part of the Total Exposure Assessment Methodology (TEAM) Study, which also collected concurrent personal inhalation monitoring samples and outdoor air samples. In Phase II and III of the study conducted between 1981 and 1984, samples were collected from adults conducting normal daily activities in industrial/chemical manufacturing and /or petroleum refining regions of the US, including Elizabeth and Bayonne, NJ, Los Angeles, CA, and Contra Costa, CA (n= 660). Arithmetic means ranged from 8.3 to 13 µg/m^3, with detection in 58 to 100% of samples.

****Su looked at Nhanes III, so did not discuss since have the 2019 CDC study.**
Reference for Updated Tables, 2019 (not in systematic review)

Centers for Disease Control and Prevention. Fourth Report on Human Exposure to Environmental Chemicals, Updated Tables, (January 2019). Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. https://www.cdc.gov/exposurereport/

3.3 Consumer Products

***Table 3- 2*. List of perchloroethylene containing products available for consumer use, from EPA's 2017 *Preliminary Information on Manufacturing, Processing, Distribution, Use, and Disposal: Tetrachloroethylene (Perchloroethylene)* (*2017*) and Use and Market Profile (*U.S. EPA 2017*)**

Product Name	Company Name (Manufacturer)	% by Weight of Chemical	Use	Summary Use	Consumer Scenario	Consumer, Commerical or Both Uses
E6000 Industrial Adhesive (Black and Clear)	Eclectic Products, Inc.	60-100%	Industrial adhesive	Adhesive - Industrial	Glues and Adhesives (small scale)	Both
E6100 Non-Slump All Colors	Eclectic Products, Inc.	65%	Industrial adhesive	Adhesive - Industrial	Glues and Adhesives (small scale)	Both
E6800	Eclectic Products, Inc.	60-100%	Industrial adhesive	Adhesive - Industrial	Glues and Adhesives (small scale)	Both
FRP Column Adhesive	Eclectic Products, Inc.	30-60%	Industrial adhesive	Adhesive - Industrial	Caulk; maybe also Glues and Adhesives	Both
E6100 Black	Eclectic Products, Inc.	60-100%	Industrial adhesive	Adhesive - Industrial	Glues and Adhesives (small scale)	Both
E6100 Clear	Eclectic Products, Inc.	30-60%	Industrial adhesive	Adhesive - Industrial	Glues and Adhesives (small scale)	Both
E6100 Gray	Eclectic Products, Inc.	60-100%	Industrial adhesive	Adhesive - Industrial	Glues and Adhesives (small scale)	Both
E6100 White	Eclectic Products, Inc.	60-100%	Industrial adhesive	Adhesive - Industrial	Glues and Adhesives (small scale)	Both

Amazing GOOP II MAX	Eclectic Products, Inc.	60-100%	Adhesive	Adhesive - Light repair	Glues and Adhesives (small scale)	Both
Amazing GOOP Trim Repair	Eclectic Products, Inc.	60-100%	Adhesive	Adhesive - Light repair	Glues and Adhesives (small scale)	Both
Primetime Adhesive	Sullivan Supply, Inc.	15%	Livestock grooming adhesive	Adhesive - Livestock grooming	Spray fixative and finishing spray coatings	Both
Cable Clean RD	CRC Industries, Inc.	90-100%	Cable cleaner	Aerosol degreaser	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Cleaner - Degreaser, Non Flammable (Aerosol)	Ashburn Chemical Technologies	30-60%	Cleaner and degreaser	Aerosol degreaser	Degreaser	Both
18 Oz Terand Coil Clnr Solvent-Based C	CPC	40-60%	Coil cleaner	Aerosol degreaser	Degreaser	Both
AST Super Dry II	Anti-Seize Technology	60-100%	Degreaser	Aerosol degreaser	Degreaser	Both
Heavy Duty Degreaser	CRC Industries, Inc.	80-90%	Degreaser	Aerosol degreaser	Degreaser	Both
Quick Clean Safety Solvent and Degreaser	CRC Industries, Inc.	90-100%	Degreaser	Aerosol degreaser	Degreaser	Both
Aerosol Degreasing Solvent EF	Nu-Calgon Wholesaler, Inc.	85-95%	Degreaser	Aerosol degreaser	Degreaser	Both
142LA Ignition & Wire Dryer	Permatex, Inc.	80-90%	Demoistures ignition and wire	Aerosol degreaser	Degreaser	Both

Mag 1 Electric Motor Cleaner 445	Warren Distribution, Inc.	98%	Electric motor cleaner	Aerosol degreaser	Degreaser	Both
Tool Crib Electric Motor and Contact Cleaner	Seymour of Sycamore	97%	Electrical cleaner	Aerosol degreaser	Degreaser	Both
B900, Berkebile Electric Contact Cleaner	The Berkebile Oil Company, Inc.	>95%	Electrical cleaner	Aerosol degreaser	Degreaser	Both
GB Electrical Degreaser	Power Products LLC (dba Gardner Bender)	97.50%	Electrical degreaser	Aerosol degreaser	Degreaser	Both
Gunk Electric Motor Contact Cleaner - Energized Equipment	RSC Chemical Solutions, a division of Radiator Specialty Company	90-100%	Energized cleaner	Aerosol degreaser	Degreaser	Both
Lectra-Motive Electric Parts Cleaner	CRC Industries, Inc.	90-100%	Energized electrical cleaner	Aerosol degreaser	Degreaser	Both
Electrical Parts Cleaner	CRC Industries, Inc.	90-100%	Energized electrical cleaner	Aerosol degreaser	Degreaser	Both
Lectra Clean Heavy Duty Energized Electrical Parts Degreaser	CRC Industries, Inc.	90-100%	Energized electrical cleaner	Aerosol degreaser	Degreaser	Both
Lectra Clean Heavy Duty Electrical Parts Degreaser	CRC Industries, Inc.	90-100%	Energized electrical cleaner	Aerosol degreaser	Degreaser	Both
Clean Up Aerosol	Jet-Lube, Inc.	NA	General purpose degreaser	Aerosol degreaser	Degreaser	Both
Marine Cleaner and Degreaser	CRC Industries, Inc.	90-100%	Marine - Cleaner and degreaser	Aerosol degreaser	Degreaser	Both
Quicksilver Marine Parts Degreaser and Cleaner	Mercury Marine	75-80%	Marine - Cleaner and degreaser	Aerosol degreaser	Degreaser	Both

LOCTITE SF 7611 PARTS CLEANER known as Loctite(R) Pro Strength Parts	Henkel Corporation	60-100%	Parts cleaner	Aerosol degreaser	Degreaser	Both
Electro Kleen	Superior Chemical Corp.	30-60%	Solvent cleaner	Aerosol degreaser	Degreaser	Both
Cool-Cut	Anti-Seize Technology	90-100%	Cutting tool coolant	Aerosol lubricant	Spray lubricant	Both
Penetrating Lube	Ashburn Chemical Technologies	60-100%	Lubricant	Aerosol lubricant	Spray lubricant	Both
Grease Gun in a Can	K-Chem, Inc.	5-10%	Lubricant	Aerosol lubricant	Spray lubricant	Both
Nut Buster	K-Chem, Inc.	NA	Lubricant	Aerosol lubricant	Spray lubricant	Both
80-695 Heavy Duty Silicone	Kimball Midwest	30-40%	Lubricant	Aerosol lubricant	Spray lubricant	Both
L2 Moisture Displacer/Deep Penetrant	Sprayway, Inc.	40-60%	Lubricant	Aerosol lubricant	Spray lubricant	Both
Break Away	Superior Chemical Corp.	60-100%	Penetrating lubricant	Aerosol lubricant	Spray lubricant	Both
Moisture Guard	Mfg. for Excalibur	35-45%	Penetrating oil and lubricant	Aerosol lubricant	Spray lubricant	Both
Talon White Lithium Grease	Fastenal	48%	White lithium grease	Aerosol lubricant	Spray lubricant	Both
E6000 Craft (Clear, Black and White)	Eclectic Products, Inc.	60-100%	Arts and crafts; Adhesive	Arts and crafts; Adhesive	Glues and Adhesives (small scale)	Both
Aleene's Platinum Bond 7800 Adhesive	Duncan Enterprises	70%	Arts and crafts; Adhesive	Arts and crafts; Adhesive	Glues and Adhesives (small scale)	Consumer

Aleene's Platinum Bond Super Fabric Textile Adhesive	Duncan Enterprises		Arts and crafts; Adhesive	Arts and crafts; Adhesive	Glues and Adhesives (small scale)	Consumer
E6000 Shoe Dazzle	Eclectic Products, Inc.	60-100%	Arts and crafts; Adhesive	Arts and crafts; Adhesive	Glues and Adhesives (small scale)	Consumer
E6000 Jewelry & Bead Glue	Eclectic Products, Inc.	60-100%	Arts and crafts; Adhesive	Arts and crafts; Adhesive	Glues and Adhesives (small scale)	Consumer
Duncan OG 802 White Gold	Duncan Enterprises	20-30%	Solvent based metallic overglaze	Arts and crafts; Overglaze	Laquers and Stains	Both
Parts Master Brake & Parts Cleaner #1733	Aftermarket Auto Parts Alliance, Inc.	NA	Automotive - Brake cleaner	Brake Cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
AST Brake Cleaner	Anti-Seize Technology	90-100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
NAPA Mac's Brake and Brake Parts Cleaner	Ashland, Inc. or Niteo Products	>90-<100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both

Pyroil Brake Parts Cleaner	Ashland, Inc. or Niteo Products	91.78%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Carquest Brake Parts Cleaner	CRC Industries, Inc.	90-100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Brakleen Brake Parts Cleaner	CRC Industries, Inc.	90-100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Brake Cleaner. Cleaning agent. Automotive Kit.	CRC Industries, Inc.	60-100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
C32, Brake & Parts Clean	Cyclo Industries, Inc.	85-100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Pro-Strength Brake and Parts Cleaner	ITW Permatex (Devcon)	40-70%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both

Gunk Brake Parts Cleaner - Chlorinated	RSC Chemical Solutions, a division of Radiator Specialty Company	40-<50%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Johnsen's Brake Parts Cleaner	Technical Chemical Company	85-100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Berkebile 2+2 Clean Brake	The Berkebile Oil Company, Inc.	100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Service Pro Chlorinated Brake Cleaner, 4820 Chlorinated Brake Cleaner	The Penray Companies, Inc.	60-100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Chlorinated Brake Parts Cleaner	Sprayway, Inc.	90-100%	Automotive - Brake cleaner	Brake cleaner	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Rubber Roller Restorer	CleanTex	35%	Solvent	Cleaner	Degreaser	Both
E1009 Restore Black Battery Reconditioner	The Noco Company	14%	Coating	Coating	Aerosol spray paints	Both

Black Zero Rust Primer	Amteco, Inc.	10.20%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both
Blue Zero Rust Primer	Amteco, Inc.	10.63%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both
Gray Zero Rust Primer	Amteco, Inc.	10.27%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both
Green Zero Rust Primer	Amteco, Inc.	9.18%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both
Red Zero Rust Primer	Amteco, Inc.	10.20%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both
Safety Red Zero Rust Primer	Amteco, Inc.	10.00%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both

Safety Yellow Zero Rust Primer	Amteco, Inc.	9.97%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both
Tan Zero Rust Primer	Amteco, Inc.	8.79%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both
Yellow Zero Rust Primer	Amteco, Inc.	8.80%	Non flat coating	Coating	Aerosol spray paints (aerosol); Solvent based wall paint (liquid)	Both
Degreasing Solvent EF	Nu-Calgon Wholesaler, Inc.	10-20%	Degreaser	Degreaser	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Tetrachloroethylene 500ml	Consolidated Chemical & Solvents LLC	100%	Solvent	Laboratories	N/A	Both
Original Formula Alumtap	Winfield Brooks Company, Inc.	<10%	Cutting fluid	Lubricant	Non-spray lubricant	Both
Heavy Duty Mold Cleaner	CRC Industries, Inc.	90-100%	Mold cleaner	Mold cleaner, release, protectant	All-purpose spray cleaner; or Aerosol spray paint	Both

Budget Silicone Mold Release	Plastic Process Equipment, Inc.	5-10%	Mold cleaner	Mold cleaner, release, protectant	All-purpose spray cleaner; or Aerosol spray paint	Both
MR™351 Mold Cleaner Aerosol	Sprayon Products (part of Sherwin-Williams® Company)	25%	Mold cleaner	Mold cleaner, release, protectant	All-purpose spray cleaner; or Aerosol spray paint	Both
WL™941 Dry Weld Spatter Protectant Aerosol	Sprayon Products (part of Sherwin-Williams® Company)	55.40%	Protectant	Mold cleaner, release, protectant	All-purpose spray cleaner; or Aerosol spray paint	Both
Fire Ant Injector Spray	K-Chem, Inc.	NA	Fire ant killer	Pesticide - Fire ants	NA	Both
Lexel White VOC	Sashco, Inc.	30-60%	Caulk	Sealant	Caulk (Sealant)	Both
ACM™ Gutter/Narrow Seam Sealant, Aluminum Gray	ACM American Construction Metals	50.60%	Sealant	Sealant	Caulk (Sealant)	Both
ACM™ Gutter/Narrow Seam Sealant, White	ACM American Construction Metals	50%	Sealant	Sealant	Caulk (Sealant)	Both
AMERIMAX® SeamerMate® Professional Grade Permanent Gutter Seal Gray	Amerimax Home Products, Inc.	>50-<75%	Sealant	Sealant	Caulk (Sealant)	Both
AMERIMAX® SeamerMate® Professional Grade Permanent Gutter Seal White	Amerimax Home Products, Inc.	>25-<50%	Sealant	Sealant	Caulk (Sealant)	Both

Geocel® Instant Gutter Seal Gutter & Narrow Seam Sealant	Geocel Products Group A Business Unit of the Sherwin-Williams Company	49.67%	Sealant	Sealant	Caulk (Sealant)	Both
Geocel® Pro Flex® RV Flexible Sealant	Geocel Products Group A Business Unit of the Sherwin-Williams Company	42.70%	Sealant	Sealant	Caulk (Sealant)	Both
Geocel® 2000® Construction Caulking Sealant	Geocel Products Group A Business Unit of the Sherwin-Williams Company	45.51%	Sealant	Sealant	Caulk (Sealant)	Both
Geocel® Pro Flex® Tripolymer Sealant	Geocel Products Group A Business Unit of the Sherwin-Williams Company	47.50%	Sealant	Sealant	Caulk (Sealant)	Both
Geocel® 2300® Construction Tripolymer Sealant	Geocel Products Group A Business Unit of The Sherwin-Williams Company	47.50%	Sealant	Sealant	Caulk (Sealant)	Both
Geocel® S2™ Solar Panel Roof Installation Sealant (white)	Geocel Products Group A Business Unit of The Sherwin-Williams Company	47%	Sealant	Sealant	Caulk (Sealant)	Both

Geocel® 2320® Construction Tripolymer Gutter and Narrow Seam Sealant	Geocel Products Group A Business Unit of The Sherwin-Williams Company	49.70%	Sealant	Sealant	Caulk (Sealant)	Both
Geocel® 2350 MHRV™ Sealant	Geocel Products Group A Business Unit of The Sherwin-Williams Company	41.96%	Sealant	Sealant	Caulk (Sealant)	Both
Geocel® Water Shield® Caulking Sealant	Geocel Products Group A Business Unit of The Sherwin-Williams Company	45.35%	Sealant	Sealant	Caulk (Sealant)	Both
ProCOLOR SWD Tripolymer Sealant	Geocel Products Group A Business Unit of The Sherwin-Williams Company	30.16%	Sealant	Sealant	Caulk (Sealant)	Both
White Lightning® Storm Blaster® All Season Sealant, White	White Lightning Products (part of Sherwin-Williams® Company)	47%	Sealant	Sealant	Caulk (Sealant)	Both
Hornady - One Shot Primer Sealer (Lock-N-Load Primer Sealer Kit)	Hornady Manufacturing Co.	30-50%	Sealant - gun ammunition	Sealant - gun ammunition	Glues and Adhesives (small scale)	Both

Sheila Shine (Aerosol and liquid)	Sheila Shine, Inc.	10-30%	Polishing agent/burnishing compound	Stainless steel polish, aerosol	Degreaser (if spray); All-purpose liquid cleaner (if liquid)	Both
Hagerty Silversmiths' Spray Polish	W. J. Hagerty & Sons, Ltd., Inc.	NA	Compounded cleaner	Stainless steel polish, aerosol		Both [Update ML 3/1/18: changed to Both, since is avaialble on Amazone and Home Depot]
Cera Fluida Classic	Tenax Spa	50-100%	Brightener wax for natural stones	Stone/metal cleaner	All-purpose waxes and polishes	Both
Special Preparation for Polishing (paste)	Bellinzoni	[Update ML 2/28/18: MSDS lists PCE content between 70 and 85%)	Marble polish	Stone/metal cleaner	All-purpose waxes and polishes (solid); All-purpose liquid cleaner (liquid)	Both
Solid Wax	AKEMI	50-100%	Wax, stone wax	stone/metal cleaner	All-purpose waxes and polishes	Both
Husky 1229 Vandalism Mark & Stain Remover	Canberra Corp.	NA	Cleaner	Vandal mark remover	All-purpose liquid cleaner	Both
Tyme-1 Cold Parts Cleaner	CRC Industries, Inc.	50-60%	Parts cleaner	Wipe cleaner	Continuous action air freshener (E5 model) + Dermal models	Both

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