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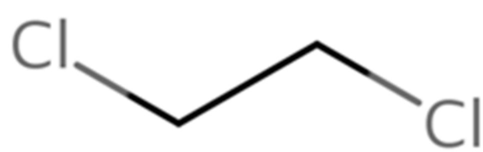
Environmental Protection Agency

Draft Occupational Exposure Assessment for 1,2-Dichloroethane

Technical Support Document for the Draft Risk Evaluation

CASRN 107-06-2



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KEY ABBREVIATIONS AND ACRONYMS

AC	Acute concentration
ADC	Average daily concentration
APDR	Acute potential dermal dose rates
APF	Assigned protection factors
ARD	Acute retained dose
BLS	Bureau of Labor Statistics (U.S.)
CAA	Clean Air Act
CARB	California Air Resources Board
CASRN	Chemical Abstracts Service Registry Number
CDR	Chemical Data Reporting
CEHD	Chemical Exposure Health Data (OSHA)
CFR	Code of Federal Regulations
CPS	Current Population Survey (BLS)
CRD	Chronic retained dose
CWA	Clean Water Act
DMR	Discharge Monitoring Report
EHS	Environment, health, and safety

EPA	Environmental Protection Agency (U.S.)
ESD	Emission scenario document
FSA	Free surface area
GS	Generic scenario
HAP	Hazardous air pollutant
HHE	Health Hazard Evaluation (NIOSH reports)
LADC	Lifetime average daily concentrations
LOD	Limit of detection
NAICS	North American Industry Classification System (codes)
NASA	National Aeronautics and Space Administration
ND	Non-detect
NEI	National Emissions Inventory
NIOSH	National Institute for Occupational Safety and Health (U.S.)
NPDES	National Pollutant Discharge Elimination System
NPDWR	National Primary Drinking Water Regulation
OCSPP	Office of Chemical Safety and Pollution Prevention (EPA)
OECD	Organisation for Economic Co-operation and Development
OEL	Occupational exposure limit
OES	Occupational exposure scenario
ONU	Occupational non-user
OPPT	Office of Pollution Prevention and Toxics (EPA)
OSHA	Occupational Safety and Health Administration
PBZ	Personal breathing zone
PEL	Permissible exposure limit
PF	Protection factors
POTW	Publicly owned treatment works
PPE	Personal protective equipment
PV	Production volume
PVC	Polyvinyl chloride
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit
SACC	Science Advisory Committee on Chemicals
SDS	Safety data sheet
SDWA	Safe Drinking Water Act
SEG	Similar exposure group
SIC	Standard Industrial Classification (codes)
SOC	Standard Occupational Classification (codes)
SpERC	Specific Environmental Release Categories
STEL	Short-term exposure limit
SUSB	U.S. Census’ Statistics of U.S. Businesses
TLV	Threshold Limit Value
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TSD	Technical support document
TWA	Time-weighted average
U.S.	United States
VOC	Volatile organic compound
WOSE	Weight of scientific evidence
WWT	Wastewater treatment

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Docket

Supporting information can be found in the public docket, Docket ID EPA-HQ-OPPT-2018-0427.

Disclaimer

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SUMMARY

This draft technical support document (TSD) accompanies the *Draft Risk Evaluation for 1,2-Dichloroethane* (U.S. EPA, 2025k). 1,2-Dichloroethane is (1) a Toxics Release Inventory (TRI)-reportable substance; (2) included on EPA's initial list of hazardous air pollutants (HAPs) under the Clean Air Act (CAA); (3) designated as a toxic pollutant under the Clean Water Act (CWA) and subject to National Primary Drinking Water Regulations (NPDWR) under the Safe Drinking Water Act (SDWA); and (4) included in the Toxic Substances Control Act (TSCA) Inventory and reported under the Chemical Data Reporting (CDR) rule. This draft assessment describes the use of reasonably available information to assess occupational exposure of workers to 1,2-dichloroethane. See Appendix C of the draft risk evaluation (U.S. EPA, 2025k) for a complete list of all TSDs and supplemental documents and files for the 1,2-dichloroethane draft risk evaluation.

Focus of the Occupational Exposure Assessment

1,2-Dichloroethane, also known as ethylene dichloride, is a colorless, oily liquid with a chloroform-like odor. It is a volatile, synthetic hydrocarbon that is used primarily as an intermediate in the synthesis of vinyl chloride and other substances such as chlorinated organics and ethylene amines. 1,2-Dichloroethane is soluble in water, miscible in most organic solvents, and incorporated into fuels as a fuel additive for the purpose of combustion research. It is used in heat resistant adhesives and low friction coatings, as a solvent in cleaning and degreasing as well as in the production of sealants, and as an oxidation inhibitor. 1,2-Dichloroethane is included on the TSCA Inventory reported under CDR and has a total production volume in the United States between 30 to 40 billion pounds (lb), from the 2020 CDR reporting period (U.S. EPA, 2025k).

Workers may be exposed to 1,2-dichloroethane during conditions of use (COUs) associated with chemical manufacturing, processing as a reactant, and industrial application of 1,2-dichloroethane-containing substances like degreasers and adhesives. This draft TSD provides the details of the assessment of the occupational exposures from each TSCA COU of 1,2-dichloroethane but does not include releases resulting from consumer uses. Releases from consumer uses of 1,2-dichloroethane-containing imported articles are addressed in the TSD *Draft Consumer Exposure Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025d).

Approach for Assessing Occupational Exposures

EPA evaluated acute, intermediate, and chronic exposures to workers. The Agency mapped 19 applicable COUs to 11 occupational exposure scenarios (OESs) based on data and information gathered during systematic review, industry outreach, and public comments. Each OES is developed based on a set of occupational activities and operational conditions such that similar occupational exposures are expected from the use(s) covered under the OES. To assess occupational exposure, EPA prefers monitoring data applicable to the chemical and the OES. If no monitoring data is available, the Agency will use analogous and surrogate data to estimate exposure or conduct exposure modeling. In this draft assessment, EPA used inhalation monitoring data from test orders and literature sources. Where no 1,2-dichloroethane monitoring data existed relevant to specific COU, EPA used modeling approaches or monitoring data from surrogate chemicals (surrogate data from trichloroethylene [TCE] was used in this assessment due to its similar vapor pressure with 1,2-dichloroethane as discussed in Sections 3.6.3 and 3.8.3).

Results for Occupational Exposures

EPA evaluated inhalation and dermal exposures to worker populations for each OES and used 1,2-dichloroethane inhalation monitoring data for 7 of the 11 OESs. Modeling was performed for three OESs where inhalation monitoring data was unavailable. For the Repackaging OES, both monitoring

data and modeling were used. For two OESs (Non-aerosol cleaning and degreasing and Industrial application of adhesives and sealants), trichloroethane monitoring data were used as surrogate data. Dermal exposures were modeled for all 11 OESs.

Inhalation exposures to 1,2-dichloroethane are expected to be higher during repackaging uses as well as the industrial uses that occur in open systems such as non-aerosol and aerosol cleaning, degreasing, and application of products such as adhesives, sealants, and lubricants. Inhalation exposures to 1,2-dichloroethane are expected to be low for closed-system processes such as manufacturing, processing as a reactant, and waste handling, treatment, and disposal uses, as well as for commercial use as a laboratory chemical. Dermal exposures to 1,2-dichloroethane from all industrial and commercial OESs are expected to be low.

Uncertainties

Uncertainties exist with the monitoring and modeling approaches used to assess 1,2-dichloroethane occupational exposures. For example, EPA used generic models and default input parameter values when site-specific data were not available, or surrogate monitoring data when directly applicable data were not available. The Agency was unable to find sufficient data on how widely or consistently engineering controls are implemented within each OES. While monitoring data reflect the controls present at the site they were collected, they may not accurately represent controls at other sites within the same OES. To account for site-to-site variability, EPA included the broadest set of available data in the assessment. However, due to data limitations, there remains uncertainty about how well the available data captures the use of engineering controls.

When modeling exposures, EPA did not identify data that correlates the use of controls to specific parameter values used in the model. However, the Agency's use of distributions for most parameters in the calculation of exposures are likely to be inclusive of a variety of controls used at the point of exposure.

1 INTRODUCTION

1.1 Overview

This draft TSD accompanies the Toxic Substances control Act (TSCA) *Draft Risk Evaluation for 1,2-Dichloroethane* (also called the "1,2-dichloroethane draft risk evaluation" or "draft risk evaluation") (U.S. EPA, 2025k) and describes exposure to workers from releases of 1,2-dichloroethane associated with TSCA COUs.

Also known as ethylene dichloride, 1,2-dichloroethane, is a colorless, oily liquid with a chloroform-like odor, is soluble in water, and miscible in most organic solvents. It is a volatile, synthetic hydrocarbon that is used primarily as an intermediate in the synthesis of vinyl chloride. It is incorporated into fuels as a fuel additive for the purpose of combustion research, used in heat resistant adhesives and low friction coatings, used as a solvent in cleaning and degreasing as well as in the production of sealants, and used as an oxidation inhibitor. It is included on the TSCA Inventory reported under CDR and has a total non-confidential production volume (PV) in the United States between 30 to 40 billion pounds (lb) annually per the 2020 CDR reporting period (U.S. EPA, 2025k). 1,2-Dichloroethane is a Toxics Release Inventory (TRI)-reportable substance, included on EPA's initial list of HAPs under the CAA, is a designated toxic pollutant under the CWA, and subject to NPDWRs under the SDWA.

The life cycle diagram (LCD) provided in Figure 1-1 shows the various life stages of the industrial, commercial, and consumer use categories included within the scope of this risk evaluation titled, *Final Scope of the Risk Evaluation for 1,2-Dichloroethane; CASRN 107-06-2* (also called the "final scope for 1,2-dichloroethane" or "final scope")(U.S. EPA, 2020). The CDR Rule under TSCA section 8(a) (see 40 CFR Part 711) requires U.S. manufacturers (including importers) to provide EPA with information on the chemicals they manufacture or import into the United States. The Agency collects CDR data approximately every 4 years with the latest collections occurring in 2020. The information in the LCD is grouped according to the CDR processing codes and use categories (including functional use codes for industrial uses and product categories for industrial, commercial, and consumer uses). This draft TSD contains additional descriptions (*e.g.,* process descriptions, worker activities, process flow diagrams) for each manufacturing, processing, use, and disposal category. The production volume reported in the final scope for 1,2-dichloroethane document was between 20 and 30 billion lb, based on total production volume of 1,2-dichloroethane in 2015 from the 2016 CDR reporting period. The range increased in the latest 2020 CDR data (the reported total production volume [PV] in 2019 was between 30–40 billion lb) (U.S. EPA, 2025k).

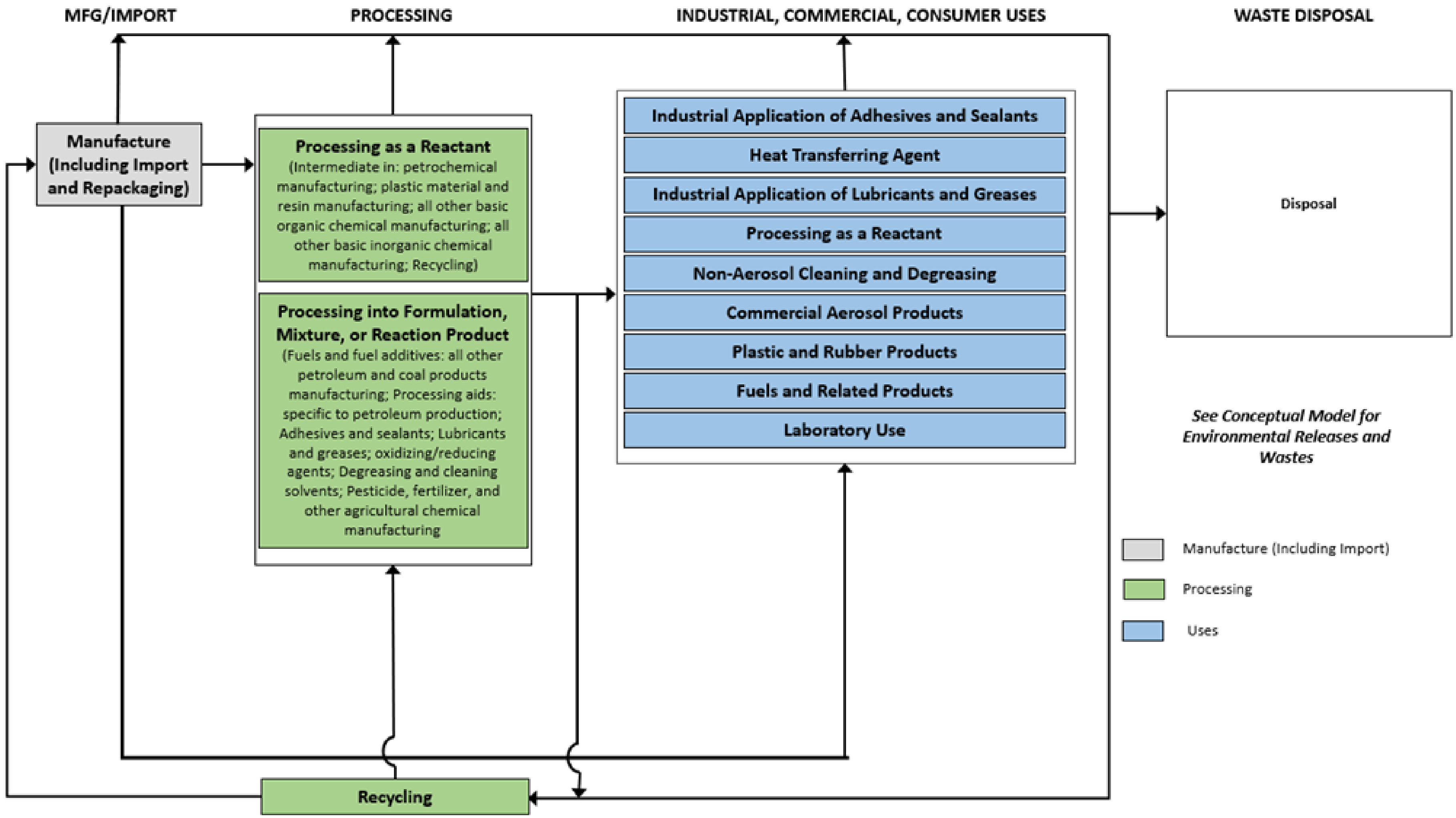

Figure 1-1. 1,2-Dichloroethane Life Cycle Diagram

This draft TSD addresses occupational exposures of 1,2-dichloroethane in industrial and commercial settings. The risks associated with these exposures are calculated in the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j), which is summarized and discussed in the *Draft Risk Evaluation for 1,2-Dichloroethane* (U.S. EPA, 2025k). Although environmental releases of 1,2-dichloroethane in industrial and commercial settings, releases in consumer settings, and the discussion of downstream environmental fate and transport factors used to estimate exposures to the general population and ecological species, are not addressed in this document, they can be found in the other TSDs that support the draft risk evaluation of 1,2-dichloroethane. In the sections that follow, the scope, methods used, and the results of the occupational exposure assessment are described in detail.

For more information on the reviewed sources used to build this assessment, as well as the evaluation strategies for these sources, refer to the *Draft Systematic Review Protocol for 1,2-Dichloroethane* (U.S. EPA, 2025l) as well as the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also referred to as the "Draft Systematic Review Protocol") (U.S. EPA, 2021a), respectively.

1.2 Scope of the Risk Evaluation

EPA assessed occupational exposures for COUs as described in Table 2-1 of the *Draft Risk Evaluation for 1,2-Dichloroethane* (U.S. EPA, 2025k). These COUs are also listed below in Table 1-1. TSCA section 3(4) defines COUs as "the circumstances, as determined by the Administrator, under which a chemical substance is intended, known, or reasonably foreseen to be manufactured, processed, distributed in commerce, used, or disposed of." EPA identifies COUs for chemicals during the scoping phase and presents them in the *Final Scope of the Risk Evaluation for 1,2-Dichloroethane; CASRN 107-06-2* (U.S. EPA, 2020)—though the COUs presented may change between the scope document and the draft risk evaluation as the assessment is conducted and additional information about the chemical is gathered. Each COU has a unique combination of life cycle stage, category, and subcategory that describes the chemical's use. As shown in Table 1-1, EPA has identified 19 COUs for 1,2-dichloroethane.

Each COU for 1,2-dichloroethane was assigned to one or more OESs that characterize its release and exposure potential. Although named for their utility when assessing occupational exposure, these scenarios are also used when assessing environmental releases from industrial and commercial facilities. For additional information about the release assessment for 1,2-dichloroethane, see the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f). "OES" is a term intended to describe the grouping or segmenting of COUs for assessment of releases and exposures. Thus, EPA may assess a group of multiple COUs together as one OES due to similarities in release and exposure sources, worker activities, and use patterns. Alternatively, the Agency may assess multiple OESs for one COU because there are different release and exposure potentials within a given COU. OES determinations are largely driven by the availability of data and modeling approaches to assess occupational releases and exposures. For example, even if there are similarities between multiple COUs, if there is sufficient data to separately assess releases and exposures for each COU, EPA would not group them into the same OES. For each OES, occupational exposure results are provided and are expected to be representative of the entire population of workers and sites involved for the given OES in the United States. Figure 1-2 depicts the ways that COUs may be mapped to OESs.

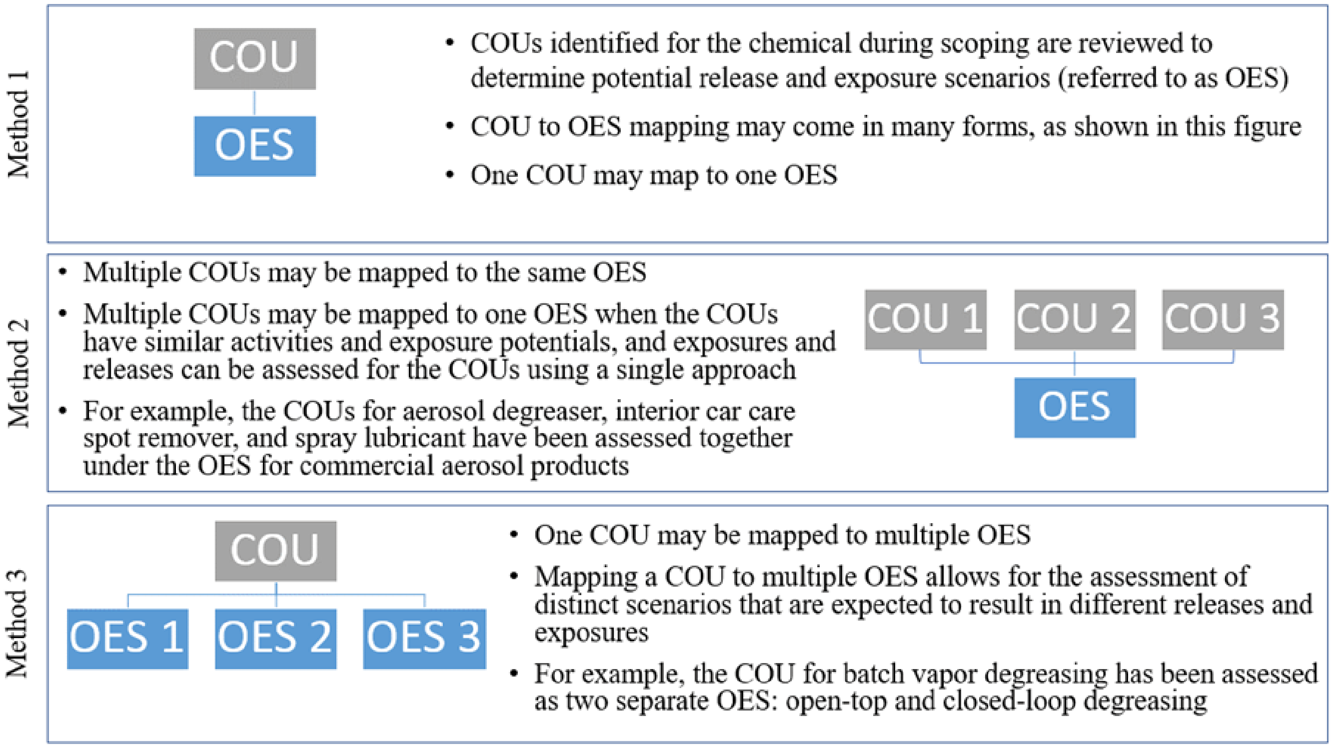

Figure 1-2. Condition of Use to Occupational Exposure Scenario Mapping

Table 1-1 shows mapping between the COUs in Table 2-1 of the *Draft Risk Evaluation for 1,2-Dichloroethane* (U.S. EPA, 2025k) to the OES assessed in this report. For 1,2-dichloroethane, EPA mapped OESs to COUs based on data and information gathered during systematic review, industry outreach, and public comments. Some of the COU categories and subcategories were grouped and assessed together in a single OES due to similarities in the processes or lack of data to differentiate between them. For example, Recycling and Processing – as a reactant categories were both assessed under the Processing as a reactant OES. This grouping minimized repetitive assessments. In one case, the COU subcategory was further delineated into multiple OESs based on expected differences in process and associated releases or exposure potentials between facilities. Specifically, the subcategory degreasing and cleaning solvents was delineated into Commercial aerosol products and Non-aerosol cleaning and degreasing. A total of 11 unique OESs were identified and mapped to 19 COUs. Table 1-1 lists each COU (defined by its unique combination of a life cycle stage, category, and subcategory) and its corresponding OES.

Table 1-1. Crosswalk of Conditions of Use (COUs) to Occupational Exposure Scenarios Assessed

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario (OES)
Manufacturing	Domestic manufacture	Domestic manufacture	Manufacturing[d]
			Manufacturing as an unintended byproduct
	Import	Import	Repackaging
Processing	Processing – as a reactant	Intermediate in: petrochemical manufacturing; plastic material and resin manufacturing; all other basic organic chemical manufacturing	Processing as a reactant
	Processing – incorporated into formulation, mixture, or reaction product	Fuels and fuel additives: all other petroleum and coal products manufacturing	Processing into formulation, mixture, or reaction product
		Processing aids: specific to petroleum production	Processing into formulation, mixture, or reaction product
		Adhesives and sealants; lubricants and greases; process regulators; degreasing and cleaning solvents; pesticide, fertilizer, and other agricultural chemical manufacturing	Processing into formulation, mixture, or reaction product
	Repackaging	Repackaging	Repackaging
	Recycling	Recycling	Processing as a reactant
Distribution in Commerce	Distribution in commerce	Distribution in commerce	Distribution in commerce[e]
Industrial Use	Adhesives and sealants	Adhesives and sealants	Industrial application of adhesives and sealants
	Functional fluids (closed systems)	Heat transferring agent	Heat transferring agent[f]
	Lubricants and greases	Solid film lubricants and greases	Industrial application of lubricants and greases
	Process regulator	Oxidation inhibitor in controlled oxidative chemical reactions	Processing as a reactant
		Catalyst moderator	Processing as a reactant
	Solvents (for cleaning and degreasing)	A component of degreasing and cleaning solvents	Commercial aerosol products
			Non-aerosol cleaning and degreasing
	Other use	Process solvent	Processing into formulation, mixture, or reaction product
Commercial Use	Plastic and rubber products	Products such as: plastic and rubber products	Plastic and rubber products[f]
	Fuels and related products	Fuels and related products	Fuels and related products[f]
	Other use	Laboratory chemical	Laboratory use

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario (OES)
Consumer Use	Plastic and rubber products	Plastic and rubber products	N/A[g]
Disposal	Disposal	Disposal	Waste handling, treatment, and disposal (landfill)
			Waste handling, treatment, and disposal (POTW)
			Waste handling, treatment, and disposal (remediation)
			Waste handling, treatment, and disposal (non-POTW WWT)
			Waste handling, treatment, and disposal (incinerator)

POTW = publicly owned treatment works; WWT = wastewater treatment
[a] Life Cycle Stage Use Definitions (40 CFR 711.3)

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

[b] These categories of COUs reflect CDR codes and broadly represent COUs for 1,2-dichloroethane in industrial and/or commercial settings.
[c] These subcategories reflect more specific uses of 1,2-dichloroethane.
[d] During the manufacture of 1,2-dichloroethane, the byproducts 1,1-dichloroethane (75-34-3), 1,1,2-trichloroethane (7900-5), *trans*-1,2-dichloroethylene (156-60-5), trichloroethylene (79-01-6), perchloroethylene (127-18-4), methylene chloride (75-09-2), and carbon tetrachloride (56-23-5) are formed, and are assessed in this draft risk evaluation. See the *Draft Byproducts Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025c).
[e] EPA considers the activities of loading and unloading of chemical product part of distribution in commerce; however, these activities were assessed as part of each use's OES. EPA's current approach for quantitively assessing releases and exposures for the remaining aspects of distribution in commerce consists of searching Department of Transportation (DOT) and National Response Center (NRC) data for incident reports pertaining to 1,2-dichloroethane distribution. These results are presented in the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f).
[f] Although these uses were identified during scoping, upon further investigation EPA made the decision to not quantitatively assess the exposures due to these uses of 1,2-dichloroethane. The rationale for not performing a quantitative assessment is described later in this section.
[g] Consumer uses are not assigned to OESs but are assessed elsewhere in this risk evaluation. See the *Draft Consumer Exposure Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025d).

As stated in table note "*d*" above, during the manufacture of 1,2-dichloroethane, the byproducts 1,1-dichloroethane (75-34-3), 1,1,2-trichloroethane (79-00-5), *trans*-1,2-dichloroethylene (156-60-5), trichloroethylene (79-01-6), perchloroethylene (127-18-4), methylene chloride (75-09-2), and carbon tetrachloride (56-23-5) are formed. Releases and associated exposures from byproducts are discussed in the *Draft Byproducts Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025c).

As stated in the table note "*f*" above, several COUs did not receive a quantitative assessment. The

Industrial use life cycle stage, Functional fluids (closed systems) category, Heat transferring agent subcategory was identified due to several safety data sheets (SDSs) for a supplemental coolant additive that lists regulatory information about 1,2-dichloroethane but provides no data on concentration of 1,2-dichloroethane in the product (Baldwin Filters, 2015). EPA confirmed with the manufacturer of the product that 1,2-dichloroethane's presence is not intentional but present only in trace amounts as an impurity in the product Versa TL-3 (EPA-HQ-OPPT-2018-0427-0066).

The second COU that did not receive a quantitative assessment in this draft risk evaluation is the Commercial Use life cycle stage, Plastic and rubber products category, Products such as: plastic and rubber products subcategory. The sources for this COU were the 2012 and 2016 CDR databases. Upon further review of the 2012 and 2016 non-confidential business information databases, it appears that this COU was based on submissions by Formosa Plastics in Point Comfort, Texas. That company reported themselves as domestic manufacturers of 1,2-dichloroethane. In 2012 and 2016 they also reported that there was potential industrial processing and use of 1,2-dichloroethane as a chemical intermediate in plastic material and resin manufacturing at less than 10 downstream sites (Industrial Sector: Plastic Material and Resin Manufacturing; Industrial Function Category: Intermediates). This presumably reflects the use of 1,2-dichloroethane as a reactant to produce vinyl chloride. However, Formosa Plastics also reported potential downstream commercial/consumer use in the Plastic and rubber products not covered elsewhere, the source of the COU in the scope document. EPA reached out to Formosa Plastics about this use, and it was confirmed that their reported commercial and consumer use of 1,2-dichloroethane was an inadvertent over-classification. Formosa also stated that there is residual 1,2-dichloroethane in vinyl chloride at low parts per million (ppm) concentrations, and residual vinyl chloride in finished PVC at ppm concentrations, leading to an expected amount of residual 1,2-dichloroethane in post-polymerization PVC in the low parts per billion levels. Any remaining 1,2-dichloroethane would be removed further during the stream stripping and drying steps that all manufactured PVC resins go through. As a result, the amount of 1,2-dichloroethane in the finished resin product is not expected to be detectable under normal conditions (EPA-HQ-OPPT-2018-0427-0025).

The next COU that did not receive a quantitative assessment is Commercial Use life cycle stage, Fuels and related products, category, Fuels and related products subcategory. 1,2-Dichloroethane was used as a lead scavenger, preventing the buildup of lead deposits within internal combustion engines, in antiknock formulations for automobiles (UNEP, 1988). While the CAA banned the sale of leaded fuel for on-road use beginning January 1, 1996, it was still permitted in specialty uses such as in high performance racing cars. However, this use was discontinued as of 2016, with the industry shifting to use of ethylene dibromide (EPA-HQ-OPPT-2018-0427-0043; EPA-HQ-OPPT-2018-0427-0006).

Also relevant to the Fuels and related products COU, EPA received a comment from the National Aeronautics and Space Administration (NASA) informing of their use of 1,2-dichloroethane in fuels for combustion research (EPA-HQ-OPPT-2018-0427-0027). EPA has determined that this specific use of 1,2-dichloroethane in fuels that NASA has reported would fall under the Commercial Use life cycle stage, Other category, Laboratory chemicals (*e.g.*, reagent) subcategory.

After identifying those OESs that will be quantitatively assessed, the next step was to describe the function of 1,2-dichloroethane within each OES. This would be utilized in mapping release and exposure data to an OES as well as applying modeling approaches. Table 1-2, provided below, is a summary; for more information on each OES, see the corresponding process descriptions in Section 3 of the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f), and worker activities in Section 3 of this draft TSD.

610 **Table 1-2. Description of the Function of 1,2-Dichloroethane for Each OES**

OES	Role/Function of 1,2-Dichloroethane
Manufacturing	This OES captures the Domestic manufacture COU category. 1,2-Dichloroethane may be produced by various methods, including by the vapor- or liquid-phase chlorination of ethylene. Additionally, 1,2-dichloroethane is manufactured as a byproduct or impurity during the intentional manufacturing of other chemical products such as dichloroethylether.
Repackaging	This OES captures the Import and repackaging COU categories. 1,2-Dichloroethane may be transported in liquid cargo barges, railcars, tank trucks, tank containers, intermediate bulk containers (IBCs)/totes, and drums. A portion of the 1,2-dichloroethane manufactured is also expected to be repackaged into smaller containers for commercial laboratory use.
Processing as a reactant	This OES captures the Processing as a reactant, Recycling, and Industrial use of oxidizing/reducing agents COU categories. 1,2-Dichloroethane is primarily used to produce vinyl chloride via thermal cracking, but can also be used to produce ethyleneamines, polyethyleneamines, and it can be used as an oxidation inhibitor. Additionally, EPA assumes that waste streams containing 1,2-dichloroethane may be recycled on-site and then re-introduced into the facility's process waste stream or recycled as a feedstock to be used in the manufacture of other chemicals.
Processing into formulation, mixture, or reaction product	This OES captures the Processing – incorporated into formulation, mixture, or reaction product COU category. Incorporation into a formulation, mixture or reaction product refers to the process of mixing or blending of several raw materials to obtain a product or mixture. 1,2-Dichloroethane is expected to be mixed or blended into adhesives and sealants, lubricants and greases, oxidizing/reducing agents, cleaning and degreasing solvents, and pesticides.
Distribution in commerce	This OES captures the Distribution in commerce COU category. 1,2-Dichloroethane is expected to be distributed in commerce for the purposes of each processing, industrial, and commercial use of 1,2-dichloroethane. EPA expects 1,2-dichloroethane to be transported from manufacturing sites to downstream processing and repackaging sites.
Industrial application of adhesives and sealants	This OES captures the Industrial use of adhesives and sealants COU category. 1,2-Dichloroethane has been identified in some industrial adhesives as residual, and it is present in heat resistant adhesives used in the aerospace industry, and in adhesives for plastics. It may also be used in waterproofing membranes that support adhesion used in extrusion coating laminating and printing, and it may be a component of sealants that protect plastics and coatings from UV degradation.
Industrial application of lubricants and greases	This OES captures the Industrial use of lubricants and greases COU category. 1,2-Dichloroethane may be present in solid film lubricants used to prevent metal to metal contact when used in the presence of conventional lubricants. It is also used in the aerospace industry in low friction and anti-knock coatings. EPA has conservatively assumed that lubricants and greases are spray applied, and so for the occupational exposure assessment this OES is assumed to be the same as the commercial

OES	Role/Function of 1,2-Dichloroethane
	aerosol products OES described below.
Non-aerosol cleaning and degreasing	This OES captures part of the Industrial use of solvents (for cleaning and degreasing) COU category. 1,2-Dichloroethane was reported to be a component of cleaning and degreasing solvents in the aerospace industry. EPA also identified 1,2-dichloroethane present in a process cleaner. EPA did not identify the primary methods used in the application of industrial solvents for cleaning and degreasing, and so for this OES vapor degreasing was assumed. Vapor degreasing is a popular cleaning method in the electronic and metal processing industries because it is effective in removing organics such as oils, greases, lubricants, coolants, and resins from crevices and hard to clean parts.
Commercial aerosol products	This OES captures part of the Industrial use of solvents (for cleaning and degreasing) COU category. 1,2-Dichloroethane was reported to be a component of cleaning and degreasing solvents in the aerospace industry. EPA also identified 1,2-dichloroethane present in a process cleaner. EPA did not identify the primary methods used in the application of industrial solvents for cleaning/degreasing, and so for this OES aerosol degreasing was assumed. Aerosol degreasing is a process that uses an aerosolized solvent spray, typically applied from a pressurized can, to remove residual contaminants for fabricated parts. A propellant is used to aerosolize the formulation, allowing it to be sprayed onto substrates. The aerosol droplets bead up on the fabricated part and then drip off, carrying away any contaminants and leaving behind a clean surface. Similarly, aerosol lubricant products use an aerosolized spray to help free frozen parts by dissolving rust and leave behind a residue to protect surfaces against rust and corrosion. In the occupational exposure assessment, this OES is used to represent exposure to lubricants and greases.
Laboratory use	This OES captures the Commercial use of laboratory chemical COU subcategory. 1,2-Dichloroethane is used as a laboratory reference standard for instrument calibration and sample preparation. It was also reported to EPA that 1,2-dichloroethane is used as a fuel additive for the purposes of research in NASA facilities.
Waste handling, treatment, and disposal	This OES captures the Disposal COU category. Each of the OES may generate waste streams of 1,2-dichloroethane that are collected and transported to third-party sites for disposal or treatment and these cases are assessed under this OES.

EPA's assessment of occupational exposures includes quantifying inhalation and dermal exposures to 1,2-dichloroethane. The Agency categorizes occupational exposures into two groups: exposures to workers and exposures to occupational non-users (ONUs). Generally, EPA distinguishes workers as working in close proximity to 1,2-dichloroethane, having direct contact and/or handling of 1,2-dichloroethane, whereas ONUs do not directly handle 1,2-dichloroethane but may be indirectly exposed to it as part of their employment. EPA evaluated inhalation exposures to both workers and ONUs and dermal exposures to workers.

2 APPROACH AND METHODOLOGY

An occupational exposure assessment was conducted for each OES specified in Table 1-1. For each OES, the following components are presented:

- **Worker Activities:** A description of the worker activities, including an assessment for potential points of worker and ONU exposure.
- **Number of Workers and ONUs:** An estimate of the number of workers and ONUs potentially exposed to the chemical for the given OES.
- **Occupational Inhalation Exposure Results:** Central tendency and high-end estimates of inhalation exposure to workers and ONUs. See Section 2.3 for a discussion of EPA's statistical analysis approach for assessing inhalation exposure.
- **Occupational Dermal Exposure Results:** Central tendency and high-end estimates of dermal exposure to workers. See Section 2.4 for a discussion of EPA's approach for assessing dermal exposure.

The approach and methodology for completing each of the above components is described in additional detail in the remainder of the section.

For workplace exposures, EPA considered exposures to both workers who directly handle 1,2-dichloroethane and ONUs who do not directly handle 1,2-dichloroethane but may be exposed to vapors, particulates, or mists that enter their breathing zone while working in locations in close proximity to where 1,2-dichloroethane is being used. EPA evaluated inhalation exposures to both workers and ONUs and dermal exposures to workers. The Agency's estimates of occupational exposure presented in this document do not assume the use of personal protective equipment (PPE); however, the effect of respiratory and dermal protection factors on EPA's occupational exposure estimates can be explored in the "Risk Reduction" tab in the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j). For more discussion on respiratory protection and glove protection, refer to Appendix F.

Figure 2-1 presents the conceptual model for exposure pathways, exposure routes, and hazards to human populations from industrial and commercial activities and uses of 1,2-dichloroethane. There is potential for exposure to workers and/or ONUs via inhalation of vapor due to the activities and uses of 1,2-dichloroethane. Exposure may occur due to fugitive emissions present during activities such as the manufacture and processing of 1,2-dichloroethane. Fugitive air emissions are emissions that are not routed through a stack and include fugitive equipment leaks from valves, pump seals, flanges, compressors, sampling connections and open-ended lines; evaporative losses from surface impoundment and spills; and releases from building ventilation systems. Exposure may also occur due to uses of 1,2-dichloroethane such as use as a laboratory chemical or the application of an adhesive or sealant containing 1,2-dichloroethane. Exposure may also occur through the dermal route for workers who handle 1,2-dichloroethane. Dermal exposure is not expected for ONUs as they are not expected to directly handle 1,2-dichloroethane.

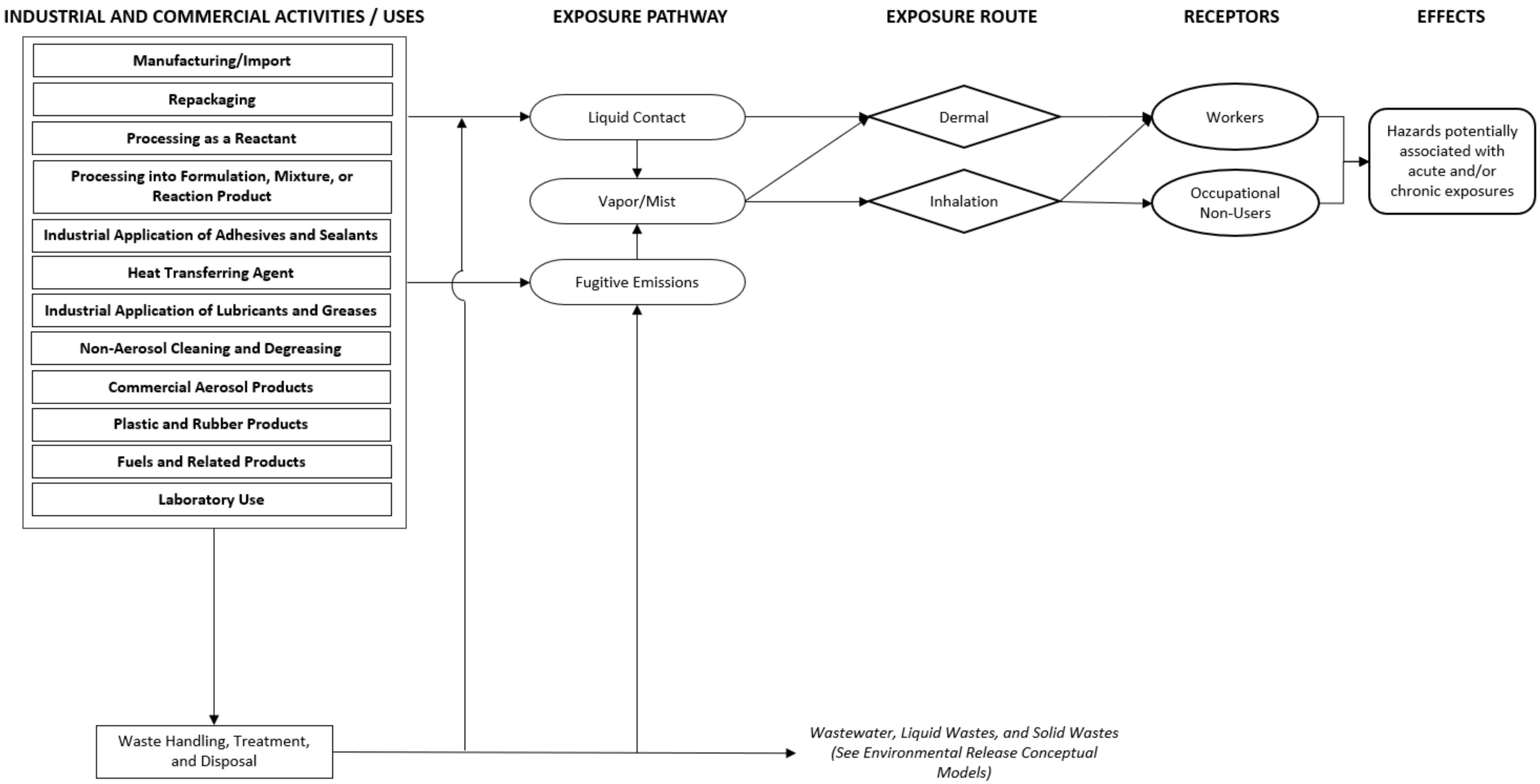

Figure 2-1. 1,2-Dichloroethane Conceptual Model for Industrial and Commercial Activities and Uses: Potential Exposure and Hazards

EPA provided occupational inhalation and dermal exposure results representative of central tendency and high-end conditions. A central tendency is assumed to be representative of occupational exposures that are expected to be typical for a given condition of use. For the draft risk evaluation, EPA used the 50th percentile (median), mean (arithmetic or geometric), mode, or midpoint values of a distribution as representative of the central tendency scenario. The Agency's preference is to provide the 50th percentile of the distribution. However, if the full distribution is not known, EPA may assume that the mean, mode, or midpoint of the distribution represents the central tendency—depending on the statistics available for the distribution.

A high-end is assumed to be representative of occupational exposures that occur at probabilities above the 90th percentile but below the exposure of the individual with the highest exposure (U.S. EPA, 1992a). For risk evaluation, EPA provided high-end results at the 95th percentile. If the 95th percentile is not available, the Agency used a different percentile greater than or equal to the 90th percentile but less than or equal to the 99.9th percentile, depending on the statistics available for the distribution. If the full distribution is not known and the preferred statistics are not available, EPA estimated a maximum or bounding estimate in lieu of the high-end.

For each OES, EPA attempted to provide central tendency and high-end full-shift time-weighted averages (TWAs) (typically as 8-hour TWAs) inhalation exposure concentrations and central tendency and high-end acute potential dermal dose rates (APDR). EPA uses the following hierarchy in selecting data and approaches for assessing occupational exposures:

1. Monitoring data:
    a. Personal and directly applicable
    b. Area and directly applicable
    c. Personal and potentially applicable or similar
    d. Area and potentially applicable or similar
2. Modeling approaches:
    a. Surrogate or analogous monitoring data
    b. Fundamental modeling approaches
    c. Statistical regression modeling approaches
3. Occupational exposure limits (these limits would likely be used jointly in an assessment):
    a. Company-specific occupational exposure limits (OELs) (for site-specific exposure assessments, for example, there is only one manufacturer who provides to EPA their internal OEL but does not provide monitoring data)
    b. Occupational Safety and Health Administration (OSHA) permissible exposure limits (PELs)
    c. Voluntary limits (American Conference of Governmental Industrial Hygienists [ACGIH] Threshold Limit Values [TLV], National Institute for Occupational Safety and Health [NIOSH] Recommended Exposure Limits [REL], Occupational Alliance for Risk Science (OARS) workplace environmental exposure level (WEEL) [formerly by AIHA])

For 1,2-dichloroethane, EPA used the estimated central tendency and high-end full-shift TWA inhalation exposure concentrations and APDR to calculate exposure metrics required for risk evaluation. Exposure metrics for inhalation exposures include acute concentrations (AC), intermediate average daily concentrations ($ADC_{intermediate}$), average daily concentrations (ADC), and lifetime average daily concentrations (LADC). Exposure metrics for dermal exposures include APDR, acute retained dose (ARD), chronic retained dose (CRD) non-cancer, and chronic retained dose (CRD) cancer. Relevant equations and sample calculations can be found in Appendix B. With exposure estimates identified for all OESs using monitoring data and modeling, occupational exposure limits were not used in this assessment.

See the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j), "Inhalation Exposure" tab, for a summary of the inhalation data used in this assessment. Click on the "Dermal Exposure" tab for details on how dermal exposure was estimated for this draft risk evaluation.

2.1 Identifying Worker Activities

EPA performed a literature search to identify worker activities that could potentially result in occupational exposures. Where worker activities were unclear or not available, the Agency referenced relevant emission scenario document (ESDs) or generic scenarios (GSs). Worker activities for each condition of use can be found for each OES in Section 3. This section also discusses PPE typically worn by workers and ONUs, if available, though EPA's occupational exposure estimates do not assume the use of PPE. However, the effect of respiratory protection and dermal protection factors on EPA's occupational exposure estimates can be explored in the "Risk Reduction" tab of the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j). For more discussion on respiratory protection and glove protection, refer to Appendix F.

2.2 Estimating Number of Workers and Occupational Non-Users

Where available, EPA used CDR data to provide a basis to estimate the number of workers and ONUs. The Agency supplemented the available CDR data with U.S. economic data using the following method:

1. Identify the North American Industry Classification System (NAICS) codes for the industry sectors associated with these uses.
2. Estimate total employment by industry/occupation combination using the Bureau of Labor Statistics' Occupational Employment Statistics data (BLS Data).
3. Refine the Occupational Employment Statistics estimates where they are not sufficiently granular by using the U.S. Census' Statistics of U.S. Businesses (SUSB) (SUSB Data) data on total employment by 6-digit NAICS.
4. Use market penetration data to estimate the percentage of employees likely to be using 1,2-dichloroethane instead of other chemicals.
5. Where market penetration data are not available, use the estimated workers/ONUs per site in the 6-digit NAICS code and multiply by the number of sites estimated from CDR, TRI, Discharge Monitoring Report (DMR) and/or National Emissions Inventory (NEI). In DMR data, sites report Standard Industrial Classification (SIC) codes rather than NAICS codes; therefore, EPA mapped each reported SIC code to a NAICS code for use in this analysis.
6. Combine the data generated in Steps 1 through 5 to produce an estimate of the number of employees using 1,2-dichloroethane in each industry/occupation combination and sum these to arrive at a total estimate of the number of employees with exposure within the COU.

There are uncertainties surrounding the estimated number of workers potentially exposed to 1,2-dichloroethane. First, BLS employment data for each industry/occupation combination are only available at the 3-, 4-, or 5-digit NAICS level—rather than at the full 6-digit NAICS level. This lack of specificity could result in an overestimate of the number of exposed workers if some 6-digit NAICS are included in the less granular BLS estimates but are not likely to use 1,2-dichloroethane for the assessed applications. EPA addressed this issue by refining the Occupational Employment Statistics data using total employment data from the U.S. Census' SUSB. However, this approach assumes that the distribution of occupation types (Standard Occupational Classification, or SOC, codes) in each 6-digit NAICS is equal to the distribution of occupation types at the parent 5-digit NAICS level. If the distribution of workers in occupations with 1,2-dichloroethane exposure differs from the overall distribution of workers in each NAICS, then this approach will result in inaccuracy. The effects of this uncertainty on the number of worker estimates are unknown, as the uncertainties may result in either over or underestimation of the estimates depending on the actual distribution.

Second, EPA's determinations of industries (represented by NAICS codes) and occupations (represented by SOC codes) that are associated with the OESs assessed in this report are based on EPA's understanding of how 1,2-dichloroethane is used in each industry. The designations of which industries and occupations have potential exposures is a matter of professional judgment; therefore, the possibility exists for the erroneous inclusion or exclusion of some industries or occupations. This may result in inaccuracy but would be unlikely to systematically either overestimate or underestimate the count of exposed workers.

2.3 Estimating Inhalation Exposures

2.3.1 Inhalation Monitoring Data

EPA reviewed workplace inhalation monitoring data collected by government agencies such as OSHA and NIOSH, monitoring data found in published literature (*i.e.*, personal exposure monitoring data and area monitoring data), and monitoring data submitted via test orders and public comments. Studies were evaluated using the evaluation strategies laid out in the *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2018). Data and studies considered in this assessment can be found in *Draft Systematic Review Protocol for 1,2-Dichloroethane* (U.S. EPA, 2025l), and in the "Inhalation Exposure" tab of the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j).

Exposures are calculated from the monitoring datasets provided in the sources depending on the size of the dataset. For datasets with six or more data points, central tendency and high-end exposures were estimated using the 50th and 95th percentiles. For datasets with three to five data points, central tendency exposure was calculated using the 50th percentile and the maximum was presented as the high-end exposure estimate. For datasets with two data points, the midpoint was presented as a midpoint value and the higher of the two values was presented as a higher value. Finally, datasets with only one data point presented the single exposure value. For datasets including exposure data that were reported as below the limit of detection (LOD), EPA estimated the exposure concentrations for these data, following EPA's *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994), which recommends using the $\frac{LOD}{\sqrt{2}}$ if the geometric standard deviation of the data is less than 3.0 and $\frac{LOD}{2}$ if the geometric standard deviation is 3.0 or greater.

If the 8-hour TWA personal breathing zone (PBZ) monitoring samples were not available, area samples were used for exposure estimates.

For each OES, EPA endeavored to distinguish exposures for workers and ONUs. A primary difference between workers and ONUs is that workers work in close proximity to 1,2-dichloroethane and may handle and have direct contact with 1,2-dichloroethane, while ONUs do not directly handle 1,2-dichloroethane but may be indirectly exposed to it as part of their employment. EPA recognizes that worker job titles and activities may vary significantly from site to site; therefore, the Agency typically identified samples as worker samples unless it was explicitly clear from the job title (*e.g.*, inspectors) and the description of activities in the report that the employee was not directly involved in the scenario. Samples from employees determined not to be directly involved in the scenario were designated as ONU samples. Where EPA was not able to estimate ONU inhalation exposure from monitoring data or models, ONU exposure was assumed to be equivalent to the central tendency experience by workers for the corresponding OES.

The primary strength of the approach is that the monitoring data are chemical-specific and directly applicable to the exposure scenario. The use of applicable monitoring data is preferable to other assessment approaches such as modeling or the use of OELs/PELs.

The principal limitation of the monitoring data is the uncertainty in the representativeness of the data due to some scenarios having limited exposure monitoring data in literature. Where few data are available, the assessed exposure levels are unlikely to be representative of worker exposure across the entire job category or industry. This may particularly be the case when monitoring data were available for only one site. Additionally, site locations may introduce uncertainty, because OSHA and NIOSH reports tend to target facilities with expected higher exposures. Differences in work practices and engineering controls across sites can introduce variability and limit the representativeness of monitoring data.

Age of the monitoring data can also introduce uncertainty due to differences in workplace practices and equipment used at the time the monitoring data were collected compared to those currently in use. Therefore, older data may overestimate or underestimate exposures, depending on these differences. The effects of these uncertainties on the occupational exposure assessment are unknown, as the uncertainties may result in either overestimation or underestimation of exposures depending on the actual distribution of 1,2-dichloroethane air concentrations and the variability of work practices among different sites.

In some scenarios where monitoring data were available, EPA did not find sufficient data to determine complete statistical distributions. Ideally, the EPA will present 50th and 95th percentiles for each exposed population. In the absence of percentile data for monitoring, the mean or midpoint of the range may serve as a substitute for the 50th percentile of the actual distributions. Similarly, the highest value of a range may serve as a substitute for the 95th percentile of the actual distribution. However, these substitutes are uncertain. The effects of these substitutes on the occupational exposure assessment are unknown, as the substitutes may result in either overestimation or underestimation of exposures depending on the actual distribution.

OSHA Chemical Exposure Health Data

A key source of monitoring data is samples collected by OSHA during facility inspections. OSHA inspection data are compiled in an agency information system (OIS) for internal use. Air sampling data records from inspections are entered into the OSHA Chemical Exposure Health Database (CEHD; accessed August 7, 2025) that can be accessed online. The database includes PBZ monitoring data, area monitoring data, bulk samples, wipe samples, and serum samples. The collected samples are used for comparing to OSHA's PELs. OSHA's CEHD website indicates that they do not: perform routine inspections at every business that uses toxic/hazardous chemicals, completely characterize all exposures for all employees every day, or always obtain a sample for an entire shift. Rather, OSHA performs targeted inspections of certain industries based on national and regional emphasis programs, often attempts to evaluate worst case chemical exposure scenarios, and develop "snapshots" of chemical exposures and assess their significance (*e.g.,* comparing measured concentrations to PELs).

EPA took the following approach to analyzing OSHA CEHD:

1. **Downloaded all data for 1,2-dichloroethane from all available years in the CEHD** (generally 1984-present).
2. **Organized data by site** (group data collected at the same site together).
3. **Removed data in which all measurements taken at the site were recorded as "0" or below the LOD** and there was no other evidence such as a bulk sample that shows the presence of the chemical at the site as EPA assumed that the chemical of interest may not have been at the site at

the time of sampling. The Agency is looking for information to help clarify this approach.

4. **Removed serum samples, bulk samples, wipe samples, and blanks.** In the CEHD there were three serum samples from one manufacturing facility. These samples are not representative of the manufacturing COU, therefore were not used in the occupational exposure assessment. EPA relied on high quality and representative inhalation monitoring data from the test order to assess inhalation exposure for the manufacturing OES.
5. **Assigned each data point to an OES.** Reviewed NAICS codes, SIC codes, and as needed, company information available online, to map each sample to an OES. In some instances, EPA was not able to determine the OES from the information in the CEHD; in such cases, EPA did not use the data in the assessment. EPA also removed data determined to be for non-TSCA uses or otherwise out of scope.
6. **Combined samples from the same worker.** In some instances, OSHA inspectors will collect multiple samples from the same worker on the same day (these are indicated by sample ID numbers). In these cases, EPA combined results from each sample to construct an exposure concentration based on the totality of exposures from each sample.
7. **Addressed less than LOD samples.** Occasionally, one or all the samples associated with a single sample number measured below the limit of detection. Because the samples were often on different time scales (*e.g.*, 1 vs. 4 hours), EPA did not include these data in the statistical analysis to estimate values below the LOD as described previously in this section. Sample results from different time scales may vary greatly as short activities my cause a large, short-term exposure that when averaged over a full-shift are comparable to other full-shift data. Therefore, including data of different time scales in the analysis may give the appearance of highly skewed data when in fact the full-shift data are not skewed. Therefore, EPA performed the statistical analysis (as needed) using all the non-OSHA CEHD data for each OES and applied the approach determined by the analysis to the non-detects in the OSHA CEHD data. Where all the exposure data for an OES came from CEHD, EPA used only the 8-hour TWAs that did not include samples that measured below the LOD to perform the statistical analysis.
8. **Calculated 8-hour TWA results from combined samples.** Where the total sample time was less than 8 hours, EPA calculated an 8-hour TWA by assuming exposures were zero for the remainder of the shift.

It should be noted that the OSHA CEHD does not provide job titles or worker activities associated with the samples; therefore, EPA assumed all data were collected on workers and not ONUs.

In some cases where inhalation exposures were expected for an OES but monitoring data specific to 1,2-dichloroethane were not available, monitoring data of the same OES but from a different chemical were used as surrogate. In these cases, EPA compared the physical properties of possible surrogate chemicals to find the most appropriate surrogate, and correction factors were applied to adjust for differences in chemical properties such as vapor pressure.

Specific details related to the use of monitoring data for each COU can be found in Section 3.

2.3.2 Inhalation Exposure Modeling

Where inhalation exposures are expected for an OES but monitoring data were not available or where data were not sufficiently representing the exposures for an OES, EPA utilized surrogate data or models to estimate inhalation exposures of 1,2-dichloroethane. Surrogate monitoring data are data of a different chemical but for similar activity. The usage of surrogate data was determined by comparing the physical properties of the potential surrogate chemical and 1,2-dichloroethane and examining the activities occurring during the potential surrogate's sampling.

For exposure models, outputs from models may be the result of deterministic calculations, stochastic calculations, or a combination of both deterministic and stochastic calculations. For each OES with modeled inhalation exposures, EPA followed these steps to estimate exposures:

1. Identified worker activities/sources of exposures from process.
2. Identified or developed relevant models for estimating exposures from each source.
3. Identified model input parameter values from relevant literature sources, including activity durations associated with sources of exposures.
4. If a range of input values was available for an input parameter, determined the associated distribution of input values.
5. Calculated exposure concentrations associated with each activity.
6. Calculated full-shift TWAs based on the exposure concentration and activity duration associated with each exposure source.
7. Calculated exposure metrics (AC, SCDC, ADC, LADC) from full-shift TWAs.

For exposure models that utilized stochastic calculations, EPA performed a Monte Carlo simulation using the Palisade @Risk Industrial Edition, Version 7.0.0 software with 100,000 iterations and the Latin Hypercube sampling method. Detailed descriptions of the model approaches used for each OES, model equations, input parameter values, and associated distributions are provided in Section 3 and Appendix E.

2.3.3 Acute, Intermediate, and Chronic (Cancer and Non-Cancer) Inhalation Exposure

For each COU, the estimated TWA exposures were used to calculate acute exposure concentrations, intermediate average daily concentrations ($ADC_{intermediate}$), ADCs for chronic, non-cancer risks, and LADCs. These calculations require additional parameter inputs, such as years of exposure, exposure duration and frequency, and lifetime years.

For the final exposure result metrics, each of the input parameters (*e.g.*, air concentrations, working years, exposure frequency, lifetime years) may be a point estimate (*i.e.*, a single descriptor or statistic, such as central tendency or high-end) or a full distribution. EPA considered the following three general approaches for estimating the final exposure result metrics:

- Deterministic calculations: EPA used combinations of point estimates of each parameter to estimate a central tendency and high-end for each final exposure metric result. The Agency documented the method and rationale for selecting parametric combinations to be representative of central tendency and high-end.
- Probabilistic (stochastic) calculations: EPA used Monte Carlo simulations using the full distribution of each parameter to calculate a full distribution of the final exposure metric results and selecting the 50th and 95th percentiles of this resulting distribution as the central tendency and high-end, respectively.
- Combination of deterministic and probabilistic calculations: EPA had full distributions for some parameters but point estimates of the remaining parameters. For example, the Agency used Monte Carlo modeling to estimate exposure concentrations but only had point estimates of exposure duration and frequency, and lifetime years. In this case, EPA documented the approach and rationale for combining point estimates with distribution results for estimating central tendency and high-end results.

Equations, parameter inputs, and sample calculations for these exposures can be found in Appendix B and Appendix C, respectively.

2.4 Dermal Exposure Approach and Methodology

Dermal exposure data were not reasonably available for the conditions of use in the assessment. Because 1,2-dichloroethane is a volatile liquid that readily evaporates from the skin, EPA estimated dermal exposures using the Dermal Exposure to Volatile Liquids Model. This model determines an APDR based on an assumed amount of liquid on skin during one contact event per day and the theoretical steady-state fractional absorption for 1,2-dichloroethane. The exposure concentration is determined based on EPA's review of currently available products and formulations containing 1,2-dichloroethane. The dose estimates assume one dermal exposure event (applied dose) per work day and approximately 0.3 percent of the applied dose is absorbed through the skin, for 1,2-dichloroethane in neat form, based on fractional absorption data that was developed from a TSCA Section 4 test order (Labcorp Early Development, 2024). EPA used a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method using the Dermal Exposure to Volatile Liquids Model, in response to recommendations from the Science Advisory Committee on Chemicals (SACC; accessed October 21, 2025) on prior chemical risk evaluations such as the *Draft Risk Evaluation for 1,1-Dichloroethane* (U.S. EPA, 2025m, 2024). Specific details of the dermal exposure assessment for each OES can be found in Section 3 and equations for estimating dermal exposures can be found in Appendix D.

EPA did not assess dermal exposures to ONUs because EPA does not expect ONUs to directly handle 1,2-dichloroethane as part of their duties. Therefore, ONUs are not expected to have dermal exposures during the course of their work.

2.4.1 Acute, Intermediate, and Chronic (Cancer and Non-Cancer) Dermal Exposure

For each COU, the estimated exposures were used to calculate acute, intermediate, and chronic (non-cancer and cancer) dermal doses. These calculations require additional parameter inputs, such as years of exposure, exposure duration and frequency, and lifetime years. For the final exposure result metrics, each of the input parameters (*e.g.*, dermal doses, working years, exposure frequency, lifetime years) may be a point estimate (*i.e.*, a single descriptor or statistic, such as central tendency or high-end) or a full distribution. EPA considered three general approaches for estimating the final exposure result metrics:

- Deterministic calculations: EPA used combinations of point estimates of each parameter to estimate a central tendency and high-end for each final exposure metric result. The Agency documented the method and rationale for selecting parametric combinations to be representative of central tendency and high-end.
- Probabilistic (stochastic) calculations: EPA used Monte Carlo simulations using the full distribution of each parameter to calculate a full distribution of the final exposure metric results and selecting the 50th and 95th percentiles of this resulting distribution as the central tendency and high-end, respectively.
- Combination of deterministic and probabilistic calculations: EPA had full distributions for some parameters but point estimates of the remaining parameters. For example, the Agency used Monte Carlo modeling to estimate exposure concentrations but only had point estimates of exposure duration and frequency, and lifetime years. In such cases, EPA documented the approach and rationale for combining point estimates with distribution results for estimating central tendency and high-end results.

Equations and sample calculations for these exposures can be found in Appendix B and Appendix C, respectively.

2.5 Evidence Integration for Occupational Exposure

Evidence integration for occupational exposure assessment includes analysis, synthesis and integration of information and data to produce estimates of occupational inhalation and dermal exposures. During evidence integration, EPA considered the likely location, duration, intensity, frequency, and quantity of exposures while also considering factors that increase or decrease the strength of evidence when analyzing and integrating the data. Sources are rated with one of four possibilities: *high*, *medium*, *low*, and *uninformative*. Key factors EPA considered when integrating evidence includes the following:

1. **Data Quality:** EPA only integrated data or information rated as high, medium, or low obtained during the data evaluation phase. Data and information rated as uninformative are not used for quantitative exposure estimates. In general, higher rankings are given preference over lower ratings; however, lower ranked data may be used over higher ranked data when specific aspects of the data are carefully examined and compared. For example, a lower ranked dataset that precisely matches the OES of interest may be used over a higher ranked study that does not as closely match the OES of interest.
2. **Data Hierarchy:** EPA used both measured and modeled data to obtain accurate and representative estimates (*e.g.*, central tendency, high-end) of the occupational exposures resulting directly from a specific source, medium, or product. If available, measured exposure data are given preference over modeled data, with the highest preference given to data that are both chemical-specific and directly representative of the OES/exposure source.

EPA considered both data quality and data hierarchy when determining evidence integration strategies. For example, EPA gave preference to high-quality modeled data over low-quality measured data to estimate exposures for the Repackaging OES where only two inhalation exposure datapoints from 1976 were found (see Section 3.2.3 for more information). The final integration of the occupational exposure evidence combined decisions regarding the strength of the available information, including information on plausibility and coherence across each evidence stream.

3 OCCUPATIONAL EXPOSURE ASSESSMENT BY OES

The following sections contain process descriptions and the specific details (worker activities, analysis for determining number of workers, exposure assessment approach and results) for the assessment for each OES.

Refer to Table 1-1 to see how each OES described below pairs with the COU stated in the final scope for 1,2-dichloroethane (U.S. EPA, 2020).

For all OESs that have inhalation monitoring data, the annual and daily central tendencies and high-ends for these occupational exposures can be found in the "Inhalation Data" tab of the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j).

For those OESs that use exposure modeling, and all dermal modeling see the following supplemental documents, as applicable:

- *Draft Application of Adhesives Exposure Model for 1,2-Dichloroethane* (U.S. EPA, 2025b)
- *Draft Aerosol Products Exposure Model for 1,2-Dichloroethane* (U.S. EPA, 2025a)
- *Draft Non-Aerosol Cleaning and Degreasing Exposure Model for 1,2-Dichloroethane* (U.S. EPA, 2025h)
- *Draft Repackaging Exposure Model for 1,2-Dichloroethane* (U.S. EPA, 2025i)
- *Draft Dermal Monte Carlo Exposure Model* (U.S. EPA, 2025e)

3.1 Manufacturing

As listed in Table 1-1, this OES includes the following COU: Domestic manufacture. This section covers both intentional manufacturing of 1,2-dichloroethane and unintentional manufacturing where 1,2-dichloroethane is produced as a byproduct during another chemical process.

3.1.1 Worker Activities

The final study report published by the Vinyl Institute Consortium (Stantec ChemRisk, 2024) detailed worker activities per similar exposure group (SEG) that occurred at 1,2-dichloroethane manufacturing sites during the sampling of the provided inhalation data. EPA assumes that the activities detailed by the Vinyl Institute are applicable to 1,2-dichloroethane manufacturing facilities throughout the country, and workers may experience inhalation and dermal exposure to 1,2-dichloroethane during these tasks. The four similar exposure groups include operators, logistics technicians, laboratory technicians, and maintenance technicians.

Operators at facilities that manufacture 1,2-dichloroethane were reported to conduct process sample collection for quality assurance and control purposes, open process lines and equipment in preparation for maintenance activities, conduct process area walk-thoughts, and monitor process equipment for leaks or abnormal activities. The Vinyl Institute noted employee versatility among the operator SEG, where a single worker may conduct tasks relevant to several different SEGs. In some circumstances, particularly at smaller facilities, operators often assisted with loading and unloading tasks on a routine or as-needed basis. At facilities where 1,2-dichloroethane is manufactured only as a byproduct, there were cases of operators who filled totes with 1,2-dichloroethane byproduct as part of their routine duties. Another example of SEG overlap in individual employee activities included one operator who assisted with laboratory analysis tasks.

Logistics technicians at facilities that manufacture 1,2-dichloroethane loaded products into the process from rail cars and barges and unloaded 1,2-dichloroethane onto rail carts or totes in an "on-demand" basis (which may be weekly, monthly, or less frequently). At facilities that manufacture 1,2-dichloroethane as a byproduct, tasks were similar though loading of different types of containers were represented by this group. In addition to connecting and disconnecting lines from loading railcars, logistic technicians also facilitate the unloading of "ISO containers" that comply with the International Standard Organization [ISO] standards). Logistic technicians at byproduct facilities also conducted sample collection more frequently (per the test order summary report (Stantec ChemRisk, 2024)) than logistic technicians at other manufacturing facilities.

Laboratory technicians at manufacturing facilities handled samples and processed them for analysis under a fume hood. Typical tasks included processing samples collected from the field by other workers, and routine laboratory duties such as housekeeping, paperwork, and routine laboratory equipment maintenance.

Maintenance technicians perform a wide variety of tasks. Because equipment is typically purged prior to maintenance activities, work with open equipment does not present as high an exposure potential as may occur with other SEGs interacting with open process lines and equipment. Additionally, maintenance technicians may be assigned to multiple process areas, some of which not containing 1,2-dicholroethane processes. Routine duties performed by maintenance technicians include rounds, permitting (obtaining facility permits to do maintenance work), air monitoring, and preparation for maintenance tasks that may include preparing and setting up equipment and PPE. They also conduct instrumentation checks as well as line breaks and equipment opening. Maintenance technicians were also reported to perform routine duties such as rounds, housekeeping, paperwork, and ordering parts. They also installed, adjusted, and deconstructed equipment as well as conducted line breaks and equipment opening for maintenance tasks.

ONUs at manufacturing sites were maintenance supervisors, engineers, control board operators, project engineers and managers, senior process and technical advisors, maintenance coordinators, and environment, health, and safety (EHS) technicians. Routine tasks performed during sampling varied and included process area walk-throughs, equipment inspections, maintenance activity observations, logistics and maintenance trouble shooting, and indoor administrative and control room tasks. At sites that manufacture 1,2-dichloroethane as a byproduct, ONUs conducted computer work and monitored controls in control rooms and administrative spaces. Because ONUs do not directly handle 1,2-dichloroethane, they are expected to have lower inhalation exposures and are not expected to have dermal exposures.

According to the final study report published by the Vinyl Institute (Stantec ChemRisk, 2024), workers in production areas are required to wear the following standard PPE: fire-resistant clothing, coveralls, hard hats, hearing protection, neoprene gloves, leather gloves, safety glasses, and steel-toed boots. The report also described use of task-specific PPE by workers, such as chemical suits worn during process opening, chemical splash goggles, face shields, and full-face respirators. Note that EPA's occupational exposure estimates do *not* account for the use of PPE; however, the effect of respiratory and dermal protection factors on EPA's occupational exposure estimates can be explored in the "Risk Reduction" tab in the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j). For more discussion on respiratory protection and glove protection, refer to Appendix F.

ONUs include employees who work at the sites where 1,2-dichloroethane is manufactured but do not directly handle the chemical; therefore, they are expected to have lower inhalation exposures to not have dermal exposures through contact with liquids or solids. ONUs for this scenario include supervisors, managers, and other employees who may be in the production area but do not perform tasks that result in the same level of exposure as those workers that engage in tasks related to the manufacture of 1,2-

dichloroethane.

According to the Vinyl Institute final study report, engineering controls are present at all representative facilities but differ by process area. In production areas, facilities typically use a closed-loop sampling system so that workers can collect process samples with minimal exposure to 1,2-dichloroethane. Logistic areas, where transport and storage activities occur, may employ a vapor recovery system that removes vapors from storage vessels and implement a nitrogen purge practice which utilizes nitrogen gas to displace unwanted impurities from the system and minimize exposures during loading and unloading activities. Also reported is use of a solution spray to monitor for leaks during loading setup, alongside isolation of devices and physical barriers in loading and unloading areas (Stantec ChemRisk, 2024).

3.1.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during manufacturing (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes, from which total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 325199 – All Other Basic Organic Chemical Manufacturing;
- 325180 – Other Basic Inorganic Chemical Manufacturing; and
- 325110 – Petrochemical Manufacturing.

Table 3-1 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.1.2 of the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f).

Table 3-1. Estimated Average Number of Workers per Site Potentially Exposed to 1,2-Dichloroethane During Manufacturing

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
45	325199 – All Other Basic Organic Chemical Manufacturing	33	16
	325180 – Other Basic Inorganic Chemical Manufacturing		
	325110 – Petrochemical Manufacturing		

[a] Number of workers and occupational non-user (ONUs) per site calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.1.3 Occupational Inhalation Exposure Results

For manufacturing of 1,2-dichloroethane, EPA was provided inhalation monitoring data via a test order submission from the Vinyl Institute, which includes manufacturers and processors of 1,2-dichloroethane (Stantec ChemRisk, 2024). The test order includes 123 worker and 39 ONU full-shift (8–12 hour) PBZ samples across 5 manufacturing facilities which was used to estimate inhalation exposures. The worker samples collected were from operators, logistic technicians, maintenance technicians, and laboratory technicians. ONUs included process engineers, project engineers, supervisors, control room board operators, environmental HSTs, senior process and technical advisors, coordinators, administrators, warehouse workers, and rail workers. In addition to the full-shift samples, the report provided 109 short-term exposure limit (STEL) samples and 77 task-length samples obtained during 1,2-dichloroethane manufacturing. The STEL samples were collected over a sampling time of approximately 15 minutes to characterize peak exposures during routine tasks. Task length samples were collected over the duration of a given task. The sample duration varied based on the task. The results of these samples are presented in Table 3-3.

The test order submission also included data on the unintentional production of 1,2-dichloroethane as a byproduct during the manufacture of other chemicals. EPA identified 53 worker and 6 ONU full-shift PBZ samples from 2 facilities to estimate inhalation exposures during the unintentional production of 1,2-dichloroethane. The worker samples were collected from operators, logistic technicians, maintenance technicians, and laboratory technicians. In addition to the full-shift samples, the report provided 46 STEL samples and 21 task-length samples during the unintentional manufacturing of 1,2-dichloroethane. The results of these samples are presented in Table 3-5.

From this test order monitoring data, EPA calculated the 50th and 95th percentile 8-hour TWA concentrations to represent a central tendency and high-end estimate of potential occupational inhalation exposures, respectively, for this scenario. EPA combined data for each SEG across all sampled sites to estimate the overall central tendency and high-end inhalation exposures. Using these 8-hour TWA exposure concentrations, EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC, as described in Appendix B. The results of these calculations are shown in Table 3-2 and Table 3-3 below.

Table 3-2. 8-Hour Duration of Inhalation Exposures to 1,2-Dichloroethane During Intentional Manufacturing Based on the Vinyl Institute Consortium Test Order Data

Worker Description	Number of Samples	8-Hour TWA Exposure Concentrations		Acute Exposure Concentrations (AC)		Intermediate Average Daily Concentration ($ADC_{intermediate}$)		Average Daily Concentration (ADC)		Lifetime Average Daily Concentration (LADC)	
		Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)
Operators	53	0.48	7.3	0.33	5.0	0.24	3.6	0.22	3.4	8.9E−02	1.7
Logistics technicians	9	1.7E−02	0.24	1.2E−02	0.16	8.5E−03	0.12	7.9E−03	0.11	3.1E−03	5.7E−02
Maintenance technicians	32	4.9E−02	1.60	3.3E−02	1.1	2.4E−02	0.80	2.3E−02	0.75	9.1E−03	0.38
Laboratory technicians	29	4.7E−02	1.30	3.2E−02	0.88	2.3E−02	0.65	2.2E−02	0.61	8.7E−03	0.31
ONUs	39	1.4E−02	1.6	9.5E−03	1.1	7.0E−03	0.80	6.5E−03	0.75	2.6E−03	0.38

Table 3-3. Short-Term Inhalation Exposures to 1,2-Dichloroethane During Intentional Manufacturing Based on the Vinyl Institute Consortium Test Order Data

Sample Type	Sample Duration (minutes)	Number of Samples	Central Tendency (ppm)	High-End (ppm)
STEL	8–34	109	0.25	22
Task Length	13–352	77	0.16	12

Table 3-4. 8-Hour Inhalation Exposures to 1,2-Dichloroethane During Unintentional Manufacturing as a Byproduct Based on the Vinyl Institute Consortium Test Order Data

Worker Description	Number of Samples	8-Hour TWA Exposure Concentrations		Acute Exposure Concentrations (AC)		Intermediate Average Daily Concentration ($ADC_{intermediate}$)		Average Daily Concentration (ADC)		Lifetime Average Daily Concentration (LADC)	
		Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)
Operators	12	7.4E−02	0.27	5.0E−02	0.18	3.7E−02	0.13	3.4E−02	0.13	1.4E−02	6.5E−02
Logistics technicians	12	6.5E−02	1.7	4.4E−02	1.2	3.2E−02	0.85	3.0E−02	0.79	1.2E−02	0.41
Maintenance technicians	14	2.1E−02	0.36	1.4E−02	0.24	1.0E−02	0.18	9.8E−03	0.17	3.9E−03	8.6E−02
Laboratory technicians	9	2.6E−02	7.6E−02	1.8E−02	5.2E−02	1.3E−02	3.8E−02	1.2E−02	3.5E−02	4.8E−03	1.8E−02
ONUs	6	4.9E−03	0.16	3.3E−03	0.11	2.4E−03	8.0E−02	2.3E−03	7.5E−02	9.1E−04	3.8E−02

Table 3-5. Short-Term Inhalation Exposures to 1,2-Dichloroethane During Unintentional Manufacturing as a Byproduct Based on the Vinyl Institute Consortium Test Order Data

Sample Type	Sample Duration (minutes)	Number of Samples	Central Tendency (ppm)	High-End (ppm)
STEL	10–79	46	6.9E−02	4.7
Task length	23–437	21	0.25	22

3.1.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. The concentration evaluated for this dermal exposure is 100 percent because 1,2-dichloroethane is expected to be manufactured as a neat liquid. Table 3-6 summarizes the APDR, ARD, $ADC_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane during manufacturing. The high-end exposure doses are the 95th percentiles of the respective simulation output and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix B.

Table 3-6. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Manufacturing

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	3.2	5.5
	Acute retained dose (ARD) (mg/kg-day)	4.1E−02	6.9E−02
	Intermediate Average Daily Dose ($ADD_{intermediate}$), non-cancer (mg/kg-day)	3.0E−02	5.1E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	2.8E−02	4.7E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	1.0E−02	1.9E−02

[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.

3.2 Repackaging

As listed in Table 1-1, this OES includes the following COU: Import and repackaging

3.2.1 Worker Activities

During repackaging, worker exposures via inhalation of 1,2-dichloroethane vapors may occur when transferring 1,2-dichloroethane from the import drums into smaller containers. Workers may also be exposed via inhalation of vapor or dermal contact with liquid 1,2-dichloroethane when cleaning import drums following emptying. Workers may also be exposed via inhalation of vapor or dermal contact with liquid 1,2-dichloroethane at repackaging sites during loading and offloading from ships, trucks, totes, barges, and railcars. In these cases, activities may include connecting and disconnecting hoses during chemical transfers, purging hoses, filling storage tanks. EPA did not find information that indicates the extent that engineering controls and worker PPE are used at facilities that repackage 1,2-dichloroethane from import drums into smaller containers. Note that the Agency's occupational exposure estimates do not account for the use of PPE; however, the effect of respiratory and dermal protection factors on EPA's occupational exposure estimates can be explored in the "Risk Reduction" tab in the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j). For more discussion on respiratory protection and glove protection, refer to Appendix F of that supplemental file.

ONUs include supervisors, managers, and other employees who work at the import site, where repackaging occurs, but do not directly handle 1,2-dichloroethane. Therefore, EPA expects the ONUs to have lower inhalation exposures, lower vapor-through-skin uptake (vapor absorption through skin), and no dermal exposures compared to workers who handle the chemicals directly.

3.2.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during repackaging (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix F includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 424610 – Plastics Materials and Basic Forms and Shapes Merchant Wholesalers;
- 424690 – Other Chemical and Allied Products Merchant Wholesalers;
- 424710 – Petroleum Bulk Stations and Terminals; and
- 424720 – Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals).

Table 3-7 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.2.2 of the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f).

Table 3-7. Estimated Average Number of Workers per Site Potentially Exposed to 1,2-Dichloroethane During Repackaging

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
59	424610 – Plastics Materials and Basic Forms and Shapes Merchant Wholesalers	1	1
	424690 – Other Chemical and Allied Products Merchant Wholesalers		
	424710 – Petroleum Bulk Stations and Terminals		
	424720 – Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals)		

[a] Number of workers and occupational non-users (ONUs) per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.2.3 Occupational Inhalation Exposure Results

EPA conducted a systematic review and identified one source containing monitoring data for 1,2-dichloroethane for the Repackaging OES. The study contained two full-shift PBZ values for workers engaged in drum filling (NIOSH, 1976). Due to the lack of discrete samples, EPA used the maximum concentration to represent the high-end and the arithmetic mean as the central tendency estimate. The total number of samples was not reported. EPA did not identify any ONU PBZ samples during data evaluation. Therefore, the Agency used the central tendency from workers to represent ONU exposures. Table 3-8 presents the estimated 8-hour TWA exposures, AC, $ADC_{intermediate}$, ADC, and LADC based on this monitoring data.

Table 3-8. Inhalation Exposures of Workers to 1,2-Dichloroethane During Repackaging Based on Monitoring Data

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)
	Central Tendency	High-End	
8-hour TWA exposure concentrations	35	45	35
Acute exposure concentrations (AC) based on 8-hour TWA	24	31	24
Intermediate average daily concentration ($ADC_{intermediate}$)	17	22	17
Average daily concentration (ADC)	16	21	16
Lifetime average daily concentration (LADC)	6.5	11	6.5

Given the limited monitoring data available, which EPA does not expect to be fully representative of worker exposures during repackaging activities, an alternative approach was developed to estimate workers inhalation exposures using the July 2022 Chemical Repackaging GS (U.S. EPA, 2022). EPA used vapor generation rate and exposure duration parameters from the 1991 CEB Manual (CEB, 1991) and the EPA Mass Balance Inhalation Model to model the exposure points described in the GS, particularly for the emptying of drums, filling of containers, and cleaning of drums processes described in the process description. The EPA Mass Balance Inhalation Model estimates the concentration of the chemical in the breathing zone of the worker based on a vapor generation rate (G) for each activity. The Agency assumes that a worker can perform each of these activities during a shift (EPA assumed an 8-hour work-shift). EPA estimated the TWA inhalation exposure for a full 8-hour work-shift as an output of the Monte Carlo simulation by: (1) summing the time-weighted inhalation exposures for each of the exposure points; and (2) assuming 1,2-dichloroethane exposures were zero outside these activities. Appendix E.1 describes model equations and other input parameters used in the Monte Carlo simulation to model worker exposures for the Repackaging OES. EPA does not have an approach to model ONU exposures separately from workers exposures. Therefore, EPA used the central tendency from modeled workers inhalation exposures to represent ONU inhalation exposures.

Table 3-9 summarizes the estimated 8-hour TWA exposures, AC, $ADC_{intermediate}$, ADC, and LADC for repackaging 1,2-dichloroethane. The high-end exposures presented in Table 3-9 are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. Equations for calculating AC, $ADC_{intermediate}$, ADC, and LADC are presented in Appendix B.

The estimated exposures assume that 1,2-dichloroethane is imported to the site in its pure form and repackaged into smaller containers, with no engineering controls present. For details on expected ventilation rates, see Appendix E.1.2.10. Actual exposures may differ based on worker activities, 1,2-dichloroethane throughputs, and facility processes.

Table 3-9. Summary of Modeled Worker Inhalation Exposures for Repackaging of 1,2-Dichloroethane

Exposure Concentration Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)
	Central Tendency	High-End	
8-Hour TWA Exposure Concentration	4.9	18	4.9
Acute exposure concentrations (AC) based on 8-hour TWA	3.4	12	3.4
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	2.5	9.1	2.5
Average daily concentration (ADC) based on 8-hour TWA	0.22	4.1	0.22
Lifetime average daily concentration (LADC) based on 8-hour TWA	8.8E−02	2.1	8.8E−02

An alternative estimate for worker inhalation exposure during repackaging can be the "logistics technician" data in Table 3-2 and Table 3-4, for the Manufacturing OES. These data would be analogous data for the Repackaging OES, as they are inhalation exposure data from the same chemical but a different, but similar, OES (*i.e.*, Manufacturing OES). The tasks performed by logistics technicians at sites that manufacture 1,2-dichloroethane include barge and truck loadings and unloading. These are activities that may be done at a repackaging site as well; therefore, the worker exposures for these workers may be applicable. Use of this analogous data may not fully characterize the exposure potentials associated with repackaging, however, as the transport that occurs at a manufacturing site is likely for large quantities and may not capture activities such as drum filling and cleaning.

3.2.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent (based on fractional absorption data that was developed from a TSCA section 4 test order (Labcorp Early Development, 2024)). The concentration evaluated for this dermal exposure is 100 percent because 1,2-dichloroethane is expected to be repackaged as a neat liquid. Table 3-10 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane during repackaging. The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix B.

Table 3-10. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Repackaging

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	3.2	5.5
	Acute retained dose (ARD) (mg/kg-day)	4.1E−02	6.9E−02
	Intermediate retained dose, non-cancer	3.0E−02	5.1E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	2.8E−02	4.7E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	1.0E−02	1.9E−02

[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.

3.3 Processing as a Reactant

A majority of the 1,2-dichloroethane manufactured is used in the production of vinyl chloride. Other uses include the production of ethylene amines, 1,1,1-trichloroethane, vinylidene chloride, trichloroethylene, and perchloroethylene (Snedecor et al., 2004; UNEP, 1988).

As listed in Table 1-1, this OES includes the following COUs: Intermediate in: petrochemical manufacturing; plastic material and resin manufacturing; all other basic organic chemical manufacturing; Recycling; and Oxidation inhibitor in controlled oxidative chemical reactions. EPA combined these COUs into one OES due to similarities in expected exposure scenarios.

3.3.1 Worker Activities

The final study report published by the Vinyl Institute (Stantec ChemRisk, 2024) detailed worker activities per SEG that occurred at 1,2-dichloroethane processing sites during the sampling of the provided inhalation data. EPA assumes that the activities detailed by the Vinyl Institute are applicable to 1,2-dichloroethane processing facilities throughout the country, and workers may experience inhalation and dermal exposure to 1,2-dichloroethane during these tasks. The four SEGs include operators, logistics technicians, laboratory technicians, and maintenance technicians.

Operators at facilities that manufacture 1,2-dichloroethane were reported to conduct process sample collection for quality assurance and control purposes, open process lines and equipment in preparation for maintenance activities, conduct process area walk-thoughts, and monitor process equipment for leaks or abnormal activities. In some circumstances, particularly at smaller facilities, operators often assisted with loading and unloading tasks on a routine or as-needed basis. It is assumed that similar tasks would occur in facilities that process 1,2-dichloroethane. At some facilities that process 1,2-dichloroethane, operators assisted with unhooking rail cars and with loading and unloading trucks.

Logistic technicians loaded and unloaded trucks and railcars in addition to collecting samples and performing routine duties in their work area such as work in the control room and operating forklifts to move drums.

Laboratory technicians handled samples collected from the field by other workers and processed them for analysis under a fume hood. They also conducted routine laboratory duties such as housekeeping, paperwork, routine laboratory equipment maintenance.

Maintenance technicians perform a wide variety of tasks. Equipment is typically purged prior to maintenance activities such as even work with open equipment does not present as high an exposure potential as may occur with other SEGs interacting with open process lines and equipment. Additionally, maintenance workers may be assigned to multiple process area, some of which do not contain 1,2-dicholroethane processes. During sampling at processing facilities, maintenance technicians perform routine housekeeping, meetings, rounds, install new piping, and performed preventative maintenance tasks on equipment such as filter changes and oil changes.

ONUs at processing facilities during sampling were rail workers, mechanics, mechanic and fabrication supervisors, instrument maintenance technicians, control board operators, shift team leads, and area coordinators. Tasks included issuing permits, conducting plant rounds, moving railcars, conducting and overseeing maintenance activities, and responding to equipment malfunctions in additional to working in control rooms, administrative spaces, and completing office work. Because ONUs do not directly handle the chemical, they are expected to have lower inhalation exposures and are not expected to have dermal exposures through contact.

According to the final study report published by the Vinyl Institute (Stantec ChemRisk, 2024), workers wear the following standard PPE: fire-resistant clothing, hard hats, hearing protection, neoprene gloves, leather gloves, safety glasses, and steel toed boots. The report also mentioned task-specific PPE, such as chemical suits worn during process opening, chemical splash goggles, face shields, and full-face respirators. As stated in Section 2.1, EPA's occupational exposure estimates do not account for the use of PPE; however, the effect of respiratory and dermal protection factors on EPA's occupational exposure estimates can be explored in the "Risk Reduction" tab in the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j). For more discussion on respiratory protection and glove protection, refer to Appendix F.

According to the Vinyl Institute final study report, engineering controls are present at all representative facilities but differ by process area. In production areas, facilities typically use a closed-loop sampling system so that workers can collect process samples with minimal exposure to 1,2-dichloroethane. Logistic areas, where transport and storage activities occur, may employ a vapor recovery system which removes vapors from storage vessels and implement a nitrogen purge practice which utilizes nitrogen gas to displace unwanted impurities from the system to minimize exposures during loading and unloading activities. Also reported is use of a solution spray to monitor for leaks during loading setup, alongside isolation of devices and physical barriers in loading and unloading areas (Stantec ChemRisk, 2024).

3.3.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during the processing as a reactive intermediate (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 325199 – All Other Basic Organic Chemical Manufacturing;
- 325211 – Plastics Material and Resin Manufacturing;
- 325110 – Petrochemical Manufacturing; and
- 325180 – Other Basic Inorganic Chemical Manufacturing.

Table 3-11 summarizes the per site estimates for this OES based on the methodology described, including the potential number of sites identified in Section 1.1.

Table 3-11. Estimated Number of Workers Potentially Exposed to 1,2-Dichloroethane During Processing as a Reactant

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
90	325199 – All Other Basic Organic Chemical Manufacturing	27	15
	325211 – Plastics Material and Resin Manufacturing		
	325110 – Petrochemical Manufacturing		
	325180 – Other Basic Inorganic Chemical Manufacturing		

[a] Number of workers and occupational non-users (ONUs) per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.3.3 Occupational Inhalation Exposure Results

Occupational inhalation data for 1,2-dichloroethane during processing as a reactant were provided via a test order submission from the Vinyl Institute, which includes manufacturers and processors of 1,2-dichloroethane (Stantec ChemRisk, 2024). EPA identified 48 worker and 14 ONU full-shift PBZ samples from 2 processing facilities from this dataset to estimate inhalation exposures. The worker samples collected were from logistics technicians, who performed tasks related to shipping and receiving of chemicals in the production process, in addition to operators, maintenance technicians, and laboratory technicians. ONUs included process engineers, project engineers, supervisors, control room board operators, environmental HSTs, senior process and technical advisors, coordinators, administrators, warehouse workers, and rail workers.

EPA also reviewed inhalation data provided via a test order submission, which was existing data generated during the manufacture of an herbicide used worldwide where the 1,2-dichloroethane is used as a processing solvent (BASF, 2021). This study contained 112 worker personal sample data points and 16 ONU personal sample data points. The range of data in this source was within the range of data from the 1,2-dichloroethane test data.

While the EPA identified other data sources containing inhalation monitoring data for workers involved in the processing of 1,2-dichloroethane as a reactant, the test order data were ultimately used due to its higher data quality, more recent date, and applicability as the data were collected specifically for TSCA purposes. In addition to the full-shift samples, the test order provided 50 STEL and 26 task-length samples during the processing of 1,2-dichloroethane. The results of these samples are presented in Table 3-13. The herbicide manufacturing data are also included as a line item for comparison with the test order data.

From this monitoring data, EPA calculated the 50th and 95th percentile 8-hour TWA concentrations to represent a central tendency and high-end estimate of potential occupational inhalation exposures, respectively, for this scenario. Using these 8-hour TWA exposure concentrations, EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC as described in Appendix B. The results of these calculations are shown in Table 3-12.

Table 3-12. Inhalation Exposures to 1,2-Dichloroethane During Processing as a Reactant

Worker Description	Number of Samples	8-Hour TWA Exposure Concentrations		Acute Exposure Concentrations (AC)		Intermediate Average Daily Concentration ($ADC_{intermediate}$)		Average Daily Concentration (ADC)		Lifetime Average Daily Concentration (LADC)	
		Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)	Central Tendency (ppm)	High-End (ppm)
Operators	18	1.3E−03	4.8E−03	8.8E−04	3.3E−03	6.5E−04	2.4E−03	6.1E−04	2.2E−03	2.4E−04	1.1E−03
Logistics technicians	6	0.17	2.3	0.12	1.6	8.5E−02	1.1	7.9E−02	1.1	3.1E−02	0.55
Maintenance technicians	10	3.2E−04	2.1E−03	2.2E−04	1.4E−03	1.6E−04	1.0E−03	1.5E−04	9.8E−04	5.9E−05	5.0E−04
Laboratory technicians	14	6.9E−04	1.5E−03	4.7E−04	1.0E−03	3.4E−04	7.5E−04	3.2E−04	7.0E−04	1.3E−04	3.6E−04
ONUs	14	2.1E−04	2.6E−04	1.4E−04	1.8E0−4	1.0E−04	1.3E−04	9.8E−04	1.2E−04	3.9E−05	6.2E−05
Herbicide manufacturing	112	0.19	1.4	0.13	0.98	9.5E−02	0.72	8.9E−02	0.67	3.5E−02	0.34
Herbicide manufacturing ONUs	4	0.19	0.23	0.13	0.16	9.5E−02	0.11	8.9E−02	0.11	3.5E−02	5.5E−02

Table 3-13. Short-Term Exposures to 1,2-Dichloroethane During Processing as a Reactant

Sample Type	Number of Samples	Central Tendency (ppm)	High-End (ppm)
STEL	50	2.4E−02	31
Task Length	26	7.2E−03	11

3.3.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. The concentration evaluated for this dermal exposure is 100 percent because 1,2-dichloroethane is expected to be processed as a reactant as a neat liquid. Table 3-14 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane during manufacturing. The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix D.

Table 3-14. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Processing as a Reactant

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	3.2	5.5
	Acute retained dose (ARD) (mg/kg-day)	4.1E−02	6.9E−02
	Intermediate Retained Dose, Non-Cancer	3.0E−02	5.1E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	2.8E−02	4.7E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	1.0E−02	1.9E−02
[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.			

3.4 Processing into Formulation, Mixture, or Reaction Product

As listed in Table 1-1, this OES includes the following COUs: Fuels and fuel additives: all other petroleum and coal products manufacturing, Processing aids: specific to petroleum production, and Adhesives and sealants; Lubricants and greases; Oxidizing/reducing agents; Degreasing and cleaning solvents; Pesticide, fertilizer, and other agricultural chemical manufacturing. EPA combined these conditions of use into one OES due to similarities in expected exposure scenarios.

3.4.1 Worker Activities

Workers are potentially exposed to 1,2-dichloroethane in processing of 1,2-dichloroethane into formulations, mixtures, or reaction products during container unloading, container cleaning, equipment cleaning, and packaging of formulation into containers. They may also be exposed to vapors due to volatilization during the mixing process itself, during product sample collection and analysis, and process maintenance. EPA also received worker protections information from the U.S. Department of Energy (DOE) related to activities associated with this COU, including on the use of chemical-resistant gloves, safety glasses, Tyvek jackets, and engineering controls (DOE, 2025).

ONUs include supervisors, managers, and other employees who work at sites which process 1,2-dichloroethane into formulations, mixtures, or reaction products but do not directly handle 1,2-dichloroethane. Therefore, EPA expects ONUs to have lower inhalation exposures, and no expected dermal exposures than workers who handle the chemical directly.

3.4.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during the processing into formulation, mixture, or reaction product (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 324199 – All Other Petroleum and Coal Products Manufacturing;
- 324110 – Petroleum Refineries;
- 324191 – Petroleum Lubricating Oil and Grease Manufacturing;
- 325180 – Other Basic Inorganic Chemical Manufacturing;
- 325199 – All Other Basic Organic Chemical Manufacturing;
- 325311 – Nitrogenous Fertilizer Manufacturing;
- 325312 – Phosphatic Fertilizer Manufacturing;
- 325314 – Fertilizer (Mixing Only) Manufacturing;
- 325320 – Pesticide and Other Agricultural Chemical Manufacturing;
- 325520 – Adhesive Manufacturing; and
- 325998 – All Other Miscellaneous Chemical Product and Preparation Manufacturing.

Table 3-15 summarizes the per site estimates for this OES based on the methodology described, including the potential number of sites identified in Section 1.1. of the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f).

Table 3-15. Estimated Average Number of Workers per Site Potentially Exposed to 1,2-Dichloroethane During Processing into Formulation, Mixture, or Reaction Product

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
24	324199 – All Other Petroleum and Coal Products Manufacturing	22	12
	324110 – Petroleum Refineries		
	324191 – Petroleum Lubricating Oil and Grease Manufacturing		
	325180 – Other Basic Inorganic Chemical Manufacturing		
	325199 – All Other Basic Organic Chemical Manufacturing		
	325311 – Nitrogenous Fertilizer Manufacturing		
	325312 – Phosphatic Fertilizer Manufacturing		
	325314 – Fertilizer (Mixing Only) Manufacturing		
	325320 – Pesticide and Other Agricultural Chemical Manufacturing		
	325520 – Adhesive Manufacturing		
	325998 – All Other Miscellaneous Chemical Product and Preparation Manufacturing		

[a] Number of workers and ONUs per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.4.3 Occupational Inhalation Exposure Results

EPA used inhalation data provided via a test order submission, which was existing data generated during the manufacture of an herbicide used worldwide where the 1,2-dichloroethane is used as a processing solvent (BASF, 2021). This study contained 112 worker personal sample data points and 16 ONU personal sample data points.

While EPA identified other data sources containing inhalation monitoring data for workers involved in the processing of 1,2-dichloroethane into formulations, the inhalation monitoring data from the herbicide manufacturing were ultimately used due to the number of samples, being more representative of a worker full-shift, and it consisted of PBZ samples. Other identified data sources had medium or low data quality scores and included either area samples or short-term measurements. Due to the unloading and blending activities in the test order submission from the Vinyl Institute, and the applicability of those activities to other processes where formulation, mixing, and blending of 1,2-dichloroethane occurs, EPA finds the data from this plant to be representative of other blending and formulation operations. See Section 2 for more details on EPA's data hierarchy, which describes the Agency's preferences regarding types of monitoring data selected for use in risk assessment.

Table 3-16 summarizes the estimated 8-hour TWA exposures for vapor processing into formulation. The high-end exposures presented in Table 3-16 are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. Equations for calculating AC, $ADC_{intermediate}$, ADC, and LADC are presented in Appendix B.

Table 3-16. Inhalation Exposures of Workers and ONUs to 1,2-Dichloroethane During Processing into Formulation

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentrations	0.19	1.4	0.19	0.23

Using the 8-hour TWA exposure concentrations presented in Table 3-16, EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC as described in Appendix B. The results of these calculations are provided in
Table 3-17.

Table 3-17. Summary of Inhalation Exposures Metrics of Workers and ONUs to 1,2-Dichloroethane During Processing into Formulation

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentrations	0.19	1.4	0.19	0.23
Acute exposure concentrations (AC) based on 8-hour TWA	0.13	0.98	0.13	0.16
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	9.5E−02	0.72	9.5E−02	0.11
Average daily concentration (ADC) based on 8-hour TWA	8.9E−02	0.67	8.9E−02	0.11

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
Lifetime average daily concentration (LADC) based on 8-hour TWA	3.5E−02	0.34	3.5E−02	5.5E−02

3.4.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. EPA assessed dermal exposures using the maximum concentration expected for this OES, which is 100 percent. Table 3-18 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane. The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix B.

Table 3-18. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Processing into Formulation, Mixture or Reaction Products

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	3.2	5.5
	Acute retained dose (ARD) (mg/kg-day)	4.1E−02	6.9E−02
	Intermediate retained dose, non-cancer	3.0E−02	5.1E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	2.8E−02	4.7E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	1.0E−02	1.9E−02

[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.

3.5 Distribution in Commerce

As listed in Table 1-1, this OES includes the following COU: Distribution in commerce.

3.5.1 Worker Activities

EPA gathered COU information from sources evaluated through the systematic review process. One study showed information pertaining to the distribution of chemicals on Norwegian chemical tankers (Moen, 1991). Although the study did not contain any quantitative exposure data of 1,2-dichloroethane, it stated that workers may be exposed when repairing storage tank leaks, during the cleanup of spills occurring during transit activities, warehousing, or temporary storage. During spill cleanup workers may be exposed through inhalation of vapors from the volatilization of 1,2-dichloroethane or dermal contact with liquid or vapors of 1,2-dichloroethane.

Typically, before spill cleanup occurs, workers evaluate the spill and determine the appropriate PPE for the cleanup activities. EPA expects exposures to occur during cleanup activities such as spill containment and confinement. Spill containment involves methods used to restrict any hazardous material to its original container. These methods may include plugging, patching, or overpacking the storage container. Spill confinement involves limiting the spread of the hazardous substance release and include the following techniques: mist knockdown/vapor suppression, diversion of the spill, diking, booming, absorbing, fencing, and damming. In general, once the spill occurs, licensed containment professionals perform disposal activities of the hazardous substance.

3.5.2 Occupational Exposure Results

Exposures from spills and associated cleanup activities are not within the scope of EPA risk evaluations under TSCA and a quantitative assessment of exposure was not done. Although EPA generally considers loading and unloading activities as part of distribution in commerce, in this assessment the exposures resulting from these activities are covered within each individual OES where the activity occurs (*i.e.*, unloading of 1,2-dichloroethane at a manufacturing is covered under the Manufacturing OES). Similarly, tank cleaning activities, which occur after unloading of 1,2-dichloroethane, are also assessed as part of the individual OES where the activity occurs.

3.6 Industrial Application of Adhesives and Sealants

As listed in Table 1-1, this OES includes the following COU: Adhesives and sealants.

EPA has identified that some industrial adhesives and sealants contain 1,2-dichloroethane (EPA-HQ-OPPT-2018-0427-0018). The Aerospace Industries Association reported that a potential use for 1,2-dichloroethane includes heat resistant adhesives for primary and secondary structural and external metallic airframe parts (EPA-HQ-OPPT-2018-0427-0005). Through this process, 1,2-dichloroethane is found in industrial adhesives in amounts less than 0.1 percent (EPA-HQ-OPPT-2018-0427-0018). EPA also identified an SDS from Shinko for their Acryldine B product, which is used as an adhesive for plastics, which contains 1,2-dichloroethane (91.8%) (Shinko Plastics Co, 2010). 1,2-Dichloroethane may also be used in waterproofing membranes, water soluble polymers that support adhesion used in extrusion coating laminating and printing T (EPA-HQ-OPPT-2018-0427-0030). Lycus Ltd in El Dorado, Arizona processes 1,2-dichloroethane as a solvent in the manufacturing of three chemicals and their derivatives: substituted benzophenones, anthanilamide, and *o*-anisoyl chloride. These chemicals are marketed for use in protecting plastics and coatings from UV degradation (Earthjustice, 2019).

3.6.1 Worker Activities

Worker exposure to 1,2-dichloroethane may occur via inhalation of mist or vapors as well as dermal contact to vapors or liquid from use of adhesives and sealants during container cleaning and unloading, equipment cleaning, spraying or roll coating, and curing or drying activities.

ONUs include supervisors, managers, and other employees who work in the application area but do not directly handle or apply 1,2-dichloroethane products. ONUs are potentially exposed via inhalation while present in the application area; however, EPA expects ONUs to have lower inhalation exposures than workers who handle or apply the products and no expected dermal exposures.

3.6.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during the use of adhesives (BLS, 2023, 2018). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 322220 – Paper Bag and Coated and Treated Paper Manufacturing;
- 341111 – Electronic Computer Manufacturing;

- 341112 – Computer Storage Device Manufacturing;
- 341118 – Computer Terminal and Other Computer;
- 334210 – Telephone Apparatus Manufacturing;
- 334220 – Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing;
- 334290 – Other Communications Equipment Manufacturing;
- 334310 – Audio and Video Equipment Manufacturing;
- 334412 – Bare Printed Circuit Board Manufacturing;
- 334413 – Semiconductor and Related Device Manufacturing;
- 334416 – Capacitor, Resistor, Coil, Transformer, and Other Inductor Manufacturing;
- 334117 – Electronic Connector Manufacturing;
- 334118 – Printed Circuit Assembly (Electronic Assembly) Manufacturing;
- 334119 – Other Electronic Component Manufacturing;
- 335131 – Residential Electric Lighting Fixture Manufacturing;
- 335132 – Commercial, Industrial, and Institutional Electric Lighting Fixture Manufacturing;
- 335139 – Electric Lamp Bulb and Other Lighting Equipment Manufacturing;
- 335210 – Small Electrical Appliance Manufacturing;
- 335220 – Major Household Appliance Manufacturing;
- 335311 – Power, Distribution, and Specialty Transformer Manufacturing;
- 332312 – Motor and Generator Manufacturing;
- 335313 – Switchgear and Switchboard Apparatus Manufacturing;
- 335314 – Relay and Industrial Coating Manufacturing;
- 335910 – Battery Manufacturing;
- 335921 – Fiber Optic Cable Manufacturing;
- 335929 – Other Communication and Energy Wire Manufacturing;
- 335931 – Current-Carrying Wiring Device Manufacturing;
- 335932 – Noncurrent-Carrying Wiring Device Manufacturing;
- 335991 – Carbon and Graphite Product Manufacturing;
- 335999 – All Other Miscellaneous Electrical Equipment and Component Manufacturing;
- 336110 – Automobile and Light Duty Motor Vehicle Manufacturing;
- 336120 – Heavy Duty Truck Manufacturing;
- 336211 – Motor Vehicle Body Manufacturing;
- 336212 – Truck Trailer Manufacturing;
- 336213 – Motor Home Manufacturing;
- 336214 – Travel Trailer and Camper Manufacturing;
- 336310 – Motor Vehicle Gasoline Engine and Engine Parts Manufacturing;
- 336320 – Motor Vehicle Electrical and Electronic Equipment Manufacturing;
- 336330 – Motor Vehicle Steering and Suspension Components (expect Spring) Manufacturing;
- 335340 – Motor Vehicle Brake System Manufacturing;
- 335350 – Motor Vehicle Transmission and Power Train Parts Manufacturing;
- 335360 – Motor Vehicle Seating and Interior Trim Manufacturing;
- 335370 – Motor Vehicle Metal Stamping;
- 336390 – Other Motor Vehicle Parts Manufacturing;
- 336411 – Aircraft Manufacturing;
- 336412 – Aircraft Engine and Engine Parts Manufacturing;
- 336313 – Other Aircraft Parts and Auxiliary Equipment Manufacturing;

- 336314 – Guided Missile and Space Vehicle Manufacturing;
- 336315 – Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing;
- 335319 – Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing;
- 336611 – Ship Building and Repairing;
- 336612 – Boat Building;
- 336991 – Motorcycle, Bicycle, and Parts Manufacturing;
- 336992 – Military Armored Vehicle, Tank, and Tank Component Manufacturing; and
- 336999 – All Other Transportation Equipment Manufacturing.

Table 3-19 summarizes the per site estimates for this OES based on the methodology described, including the potential number of sites identified in Section 3.6.2 of the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f).

Table 3-19. Estimated Number of Workers Potentially Exposed to 1,2-Dichloroethane During Application of Adhesives and Sealants

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
83	322220 – Paper Bag and Coated and Treated Paper Manufacturing	42	19
	334100 – Computer and Peripheral Equipment Manufacturing		
	334200 – Communications Equipment Manufacturing		
	334300 – Audio and Video Equipment Manufacturing		
	334400 – Semiconductor and Other Electronic Component Manufacturing		
	335100 – Electric Lighting Equipment Manufacturing		
	335200 – Household Appliance Manufacturing		
	335300 – Electrical Equipment Manufacturing		
	335900 – Other Electrical Equipment and Component Manufacturing		
	336100 – Motor Vehicle Manufacturing		
	336200 – Motor Vehicle Body and Trailer Manufacturing		
	336300 – Motor Vehicle Parts Manufacturing		
	336400 – Aerospace Product and Parts Manufacturing		
	336411 – Aircraft Manufacturing		
	336600 – Ship and Boat Building		

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
	336900 – Other Transportation Equipment Manufacturing		
[a] Number of workers and occupational non-users (ONUs) per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.			

3.6.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation exposure monitoring data related to the use of 1,2-dichloroethane in adhesives and sealants. EPA used surrogate data from trichloroethylene (TCE) during use of paints, coatings, adhesives, and sealants. TCE has a similar vapor pressure of 73.5 mm Hg vs. 78.9 mm Hg for 1,2-dichloroethane; therefore, potential exposures are expected to be similar.

The TCE monitoring data were obtained from a NIOSH Health Hazard Evaluation report (HHEs) and three OSHA facility inspections (OSHA, 2017; Chrostek, 1981). These data encompass exposures from facilities using TCE in adhesive and coating applications. The data includes 22 samples for workers and 2 samples for ONUs.

Table 3-20 summarizes the estimated 8-hour TWA exposures for application of adhesives and sealants. The high-end exposures presented in Table 3-20 are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles.

Table 3-20. Summary of Worker Inhalation Exposures to 1,2-Dichloroethane for Industrial Application of Adhesives and Sealants Based on Trichloroethylene Data as a Surrogate

Exposure Point	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-hour TWA exposure concentrations	4.6	40	0.90	1.0

From the 8-hour TWA, EPA estimated the AC, $ADC_{intermediate}$, and ADC, LADC for the application of adhesives and sealants containing 1,2-dichloroethane. These exposure metrics are presented in Table 3-21. Equations for calculating AC, $ADC_{intermediate}$, and ADC, LADC are presented in Appendix B.

Table 3-21. Summary of Worker Inhalation Exposure Metrics to 1,2-Dichloroethane for Industrial Application of Adhesives and Sealants

Exposure Concentration Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentrations	4.6	40	0.90	1.0
Acute exposure concentrations (AC) based on 8-hour TWA	3.1	27	0.61	0.68
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	2.3	20	0.45	0.50
Average daily concentration (ADC) based on 8-hour TWA	2.1	18	0.42	0.47
Lifetime average daily concentration (LADC) based on 8-hour TWA	0.85	9.4	0.17	0.24

3.6.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. The concentration evaluated for this dermal exposure is 91.8 percent based on an SDS for an adhesive containing 1,2-dichloroethane (Shinko Plastics Co, 2010). EPA employed the 91.8 percent value as a high-end estimate for the presence of 1,2-dichloroethane in adhesives, despite uncertainty about such a high percentage in any adhesive product. EPA welcomes additional information (*e.g.*, SDS documents) to inform the level of 1,2-dichloroethane in adhesives. Table 3-22 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane. The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix B.

Table 3-22. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Industrial Application of Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	3.0	5.1
	Acute retained dose (ARD) (mg/kg-day)	3.7E−02	6.4E−02
	Intermediate retained dose ($ADD_{intermediate}$), non-cancer	2.7E−02	4.7E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	1.8E−02	3.6E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	6.8E−03	1.5E−02

[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.

3.7 Industrial Application of Lubricants and Greases

EPA identified an SDS for a low friction coating, also known as a solid film lubricant, containing 5 to 10 percent 1,2-dichloroethane (Everlube Products, 2019). The DOE confirmed that 1,2-dichloroethane can be present at the same 5 to 10 percent concentration in such lubricants (DOE, 2025). According to the associated product Technical Data sheet, this product is a spray applied thermally cured lubricant used to prevent metal to metal contact when used in the presence of conventional lubricants such as fuels, oils, greases, or other fluid environments (Everlube Products, 2003). According to comments from the Aerospace Industries Association, 1,2-dichloroethane is also used in low friction and anti-knock coatings for the aerospace industry (EPA-HQ-OPPT-2018-0427-0005).

As listed in Table 1-1, this OES includes the following COU: Solid film lubricants and greases.

3.7.1 Worker Activities

Workers are potentially exposed to 1,2-dichloroethane during application of lubricants and greases during container cleaning and unloading, equipment cleaning, and from inhalation of mist that may occur while spraying or otherwise applying the lubricant or grease. Exposure may also occur during the curing or drying. Workers are expected to be exposed via inhalation exposure to mists or vapors or dermal exposure to liquids.

ONUs include supervisors, managers, and other employees who work at sites which use 1,2-dichloroethane as a lubricant or grease but do not directly handle 1,2-dichloroethane. Therefore, EPA expects ONUs to have lower inhalation exposures and no expected dermal exposure than workers who handle the chemical directly.

3.7.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during the use of lubricants and greases (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 335210 – Small Electrical Appliance Manufacturing;
- 335220 – Major Household Appliance Manufacturing;
- 336110 – Automobile and Light Duty Motor Vehicle Manufacturing;
- 336120 – Heavy Duty Truck Manufacturing;
- 336211 – Motor Vehicle Body Manufacturing;
- 336212 – Truck Trailer Manufacturing;
- 336213 – Motor Home Manufacturing;
- 336214 – Travel Trailer and Camper Manufacturing;
- 336310 – Motor Vehicle Gasoline Engine and Engine Parts Manufacturing;
- 336320 – Motor Vehicle Electrical and Electronic Equipment Manufacturing;
- 336330 – Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing;
- 336340 – Motor Vehicle Brake System Manufacturing;
- 336350 – Motor Vehicle Transmission and Power Train Parts Manufacturing;
- 336360 – Motor Vehicle Seating and Interior Trim Manufacturing;
- 336370 – Motor Vehicle Metal Stamping;
- 336390 – Other Motor Vehicle Parts Manufacturing;
- 336411 – Aircraft Manufacturing;
- 336412 – Aircraft Engine and Engine Parts Manufacturing;
- 336413 – Other Aircraft Parts and Auxiliary Equipment Manufacturing;
- 336414 – Guided Missile and Space Vehicle Manufacturing;
- 336415 – Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing;

- 335419 – Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing;
- 336611 – Ship Building and Repairing;
- 336612 – Boat Building;
- 336991 – Motorcycle, Bicycle, and Parts Manufacturing;
- 336992 – Military Armored Vehicle, Tank, and Tank Component Manufacturing; and
- 336999 – All Other Transportation Equipment Manufacturing.

Table 3-23 summarizes the per site estimates for this OES based on the methodology described, including the potential number of sites identified in Section 3.7.2 of the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f).

Table 3-23. Estimated Number of Workers Potentially Exposed to 1,2-Dichoroethane During Application of Lubricants and Greases

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
4	335210 – Small Electrical Appliance Manufacturing	75	22
	335220 – Major Household Appliance Manufacturing		
	336110 – Automobile and Light Duty Motor Vehicle Manufacturing		
	335120 – Heavy Duty Truck Manufacturing		
	336211 – Motor Vehicle Body Manufacturing		
	336212 – Truck Trailer Manufacturing		
	336213 – Motor Home Manufacturing		
	336214 – Travel Trailer and Camper Manufacturing		
	336310 – Motor Vehicle Gasoline Engine and Engine Parts Manufacturing		
	336320 – Motor Vehicle Electrical and Electronic Equipment Manufacturing		
	336330 – Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing		
	336340 – Motor Vehicle Brake System Manufacturing		
	336350 – Motor Vehicle Transmission and Power Train Parts Manufacturing		
	336360 – Motor Vehicle Seating and Interior Trim Manufacturing		
	336370 – Motor Vehicle Metal Stamping		
	336390 – Other Motor Vehicle Parts Manufacturing		
	336411 – Aircraft Manufacturing		

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
4	336412 – Aircraft Engine and Engine Parts Manufacturing	75	5
	336413 – Other Aircraft Parts and Auxiliary Equipment Manufacturing		
	336414 – Guided Missile and Space Vehicle Manufacturing		
	336415 – Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing		
	335419 – Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing		
	336611 – Ship Building and Repairing		
	336612 – Boat Building		
	336991 – Motorcycle, Bicycle, and Parts Manufacturing		
	336992 – Military Armored Vehicle, Tank, and Tank Component Manufacturing		
	336999 – All Other Transportation Equipment Manufacturing		

[a] Number of workers occupational non-users (ONUs) per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.7.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation exposure monitoring data related to the use of 1,2-dichloroethane in lubricant and grease applications. Therefore, the Agency estimated inhalation exposures using EPA's Brake Servicing Near-Field/Far-Field Exposure Model. EPA used the brake servicing model as an analogous scenario for this OES due to aerosol use. Note that this approach is applied both to this OES and for Industrial and commercial aerosol products.

The near-field/far-field approach describes a scenario where an aerosol application located inside the near-field generates a mist of droplets, and indoor air movements lead to the convection of the droplets between the near-field and far-field. Workers are assumed to be exposed to droplet concentrations in the near-field, while ONUs are exposed to concentrations in the far-field (AIHA, 2009).

Based on data from the California Air Resources Board (CARB) (2000), EPA assumes each brake job requires one 14.4-oz can of aerosol brake cleaner as described in Appendix E.2. The model determines the application rate of 1,2-dichloroethane based on its weight fraction in the aerosol product. EPA uses a uniform distribution for these weight fractions, ranging from 5 to 10 percent (Everlube Products, 2019).

An 8-hour TWA is then estimated assuming no exposure occurs outside of the brake jobs. Appendix E.2 also describes the model equations and other input parameters used in the Monte Carlo simulation for this OES.

Table 3-24 summarizes the estimated 8-hour TWA exposure for the application of lubricants and greases containing 1,2-dichloroethane. The high-end exposures presented in Table 3-24 are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles.

Table 3-24. Summary of Modeled Worker Inhalation Exposures to 1,2-Dichloroethane for Industrial Application of Lubricants and Greases

Exposure Concentration Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentration	3.5	9.0	2.3	7.4

From the 8-hour TWA, EPA estimated the AC, $ADC_{intermediate}$, and ADC, LADC for the application of lubricants and greases containing 1,2-dichloroethane. These exposure metrics are presented in Table 3-25. Equations for calculating AC, $ADC_{intermediate}$, and ADC, LADC are presented in Appendix B. Note that the model's near-field results are used to estimate worker exposure, while the far-field results are used to estimate ONUs exposures.

Table 3-25. Summary of Worker Inhalation Exposure Metrics to 1,2-Dichloroethane for Industrial Application of Lubricants and Greases

Exposure Concentration Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentrations	3.5	9.0	2.3	7.4
Acute exposure concentrations (AC) based on 8-hour TWA	2.4	6.1	1.6	5.0
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	1.7	4.5	1.2	3.7
Average daily concentration (ADC) based on 8-hour TWA	1.6	4.2	1.1	3.5
Lifetime average daily concentration (LADC) based on 8-hour TWA	0.64	2.1	0.43	1.8

3.7.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. EPA assessed dermal exposures using the concentration range reported in the SDS for a low-friction coating, which is 5 to 10 percent (Everlube Products, 2019).Table 3-26 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane. The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix B.

Table 3-26. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Industrial Application of Lubricants and Greases

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	0.24	0.45
	Acute retained dose (ARD) (mg/kg-day)	3.0E−03	5.6E−03
	Intermediate retained dose ($ADD_{intermediate}$), non-cancer	2.2E−03	4.1E−03
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	2.0E−03	3.8E−03
	Chronic retained dose (CRD), cancer (mg/kg-day)	7.6E−04	1.6E−03
[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.			

3.8 Industrial and Commercial Non-Aerosol Cleaning/Degreasing

1,2-Dichloroethane is used as a component of cleaning and degreasing solvents in the aerospace industry (EPA-HQ-OPPT-2018-0427-0005). EPA also identified an SDS for 1,2-dichloroethane (99–100%) that identified use as a process cleaner (Occidental Chemical Corp, 2015).

As listed in Table 1-1, this OES includes the following COU: Part of A component of degreasing and cleaning solvents.

3.8.1 Worker Activities

Workers are potentially exposed to 1,2-dichloroethane during industrial and commercial non-aerosol cleaning and degreasing (particularly vapor degreasing) while unloading the chemical from transport containers, during degreaser operation, and during cleaning and maintenance activities. Because 1,2-dichloroethane is volatile, inhalation exposure to vapor and mist is expected to be the primary exposure route; however, dermal exposure to the liquid form may also occur.

ONUs include supervisors, managers, and other workers at sites which use 1,2-dichloroethane for non-aerosol cleaning and degreasing but do not directly handle 1,2-dichloroethane. Therefore, EPA expects ONUs to have lower inhalation exposures, and no expected dermal exposure than workers who handle the chemical directly.

3.8.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during the use cleaners and degreasers (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 336110 – Automobile and Light Duty Motor Vehicle Manufacturing;
- 336120 – Heavy Duty Truck Manufacturing;
- 336211 – Motor Vehicle Body Manufacturing;
- 336212 – Truck Trailer Manufacturing;
- 336213 – Motor Home Manufacturing;
- 336214 – Travel Trailer and Camper Manufacturing;
- 336310 – Motor Vehicle Gasoline Engine and Engine Parts Manufacturing;

- 336320 – Motor Vehicle Electrical and Electronic Equipment Manufacturing;
- 336330 – Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing;
- 336340 – Motor Vehicle Brake System Manufacturing;
- 336350 – Motor Vehicle Transmission and Power Train Parts Manufacturing;
- 336360 – Motor Vehicle Seating and Interior Trim Manufacturing;
- 336370 – Motor Vehicle Metal Stamping;
- 336390 – Other Motor Vehicle Parts Manufacturing;
- 336411 – Aircraft Manufacturing;
- 336412 – Aircraft Engine and Engine Parts Manufacturing;
- 336413 – Other Aircraft Parts and Auxiliary Equipment Manufacturing;
- 336414 – Guided Missile and Space Vehicle Manufacturing;
- 336415 – Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing;
- 336419 – Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing;
- 336611 – Ship Building and Repairing;
- 366612 – Boat Building;
- 366991 – Motorcycle, Bicycle, and Parts Manufacturing;
- 366992 – Military Armored Vehicle, Tank, and Tank Component Manufacturing; and
- 336999 – All Other Transportation Equipment Manufacturing.

Table 3-27 summarizes the per site estimates for this OES based on the methodology described, including the potential number of sites identified in Section 3.8.2 of the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f).

Table 3-27. Estimated Number of Workers Potentially Exposed to 1,2-Dichloroethane During Use of Non-Aerosol Cleaners and Degreasers

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
4	336110 – Automobile and Light Duty Motor Vehicle Manufacturing 336120 – Heavy Duty Truck Manufacturing 336211 – Motor Vehicle Body Manufacturing 336212 – Truck Trailer Manufacturing 336213 – Motor Home Manufacturing 336214 – Travel Trailer and Camper Manufacturing 336310 – Motor Vehicle Gasoline Engine and Engine Parts Manufacturing 336320 – Motor Vehicle Electrical and Electronic Equipment Manufacturing 336330 – Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing 336340 – Motor Vehicle Brake System	76	22

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
4	Manufacturing	76	22
	336350 – Motor Vehicle Transmission and Power Train Parts Manufacturing		
	336360 – Motor Vehicle Seating and Interior Trim Manufacturing		
	336370 – Motor Vehicle Metal Stamping		
	336390 – Other Motor Vehicle Parts Manufacturing		
	336411 – Aircraft Manufacturing		
	336412 – Aircraft Engine and Engine Parts Manufacturing		
	336413 – Other Aircraft Parts and Auxiliary Equipment Manufacturing		
	336414 – Guided Missile and Space Vehicle Manufacturing		
	336415 – Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing		
	336419 – Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing		
	336611 – Ship Building and Repairing		
	366612 – Boat Building		
	366991 – Motorcycle, Bicycle, and Parts Manufacturing		
	366992 – Military Armored Vehicle, Tank, and Tank Component Manufacturing		
	336999 – All Other Transportation Equipment Manufacturing		

[a] Number of workers and occupational non-users (ONUs) per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.8.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation exposure monitoring data related to the use of 1,2-dichloroethane in non-aerosol degreasers. The Agency used surrogate data from TCE during Batch Open-Top Vapor Degreasing. EPA has uncertainty regarding the OES for the Solvent, cleaning, and degreasing COU for 1,2-dichloroethane. The Agency selected open-top vapor degreasing based on availability of surrogate monitoring data and because that this process presents a conservative estimate of exposure due to its higher exposure potential. TCE was chosen as surrogate due to its very similar vapor pressure of 73.5 mm Hg vs. 78.9 mm Hg for 1,2-dichloroethane; therefore, potential exposures are expected to be similar for the same activity. TCE also has a robust dataset, with 113 samples for workers and 10 samples for ONUs.

The TCE monitoring data were obtained from NIOSH HHEs. These data encompass exposures from various industries, such as metal tube production, valve manufacturing, jet and rocket engine manufacturing, air conditioning preparation and assembly, and air conditioning motor parts (Barsan, 1991; Seitz and Driscoll, 1989; Daniels et al., 1988; NIOSH, 1984, 1982; Ruhe et al., 1981; Lewis, 1980; Gilles et al., 1977; Rosensteel and Lucas, 1975; NIOSH, 1973).

Table 3-28 summarizes the estimated 8-hour TWA exposures for vapor degreasing. The high-end exposures presented in Table 3-28 are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles.

Table 3-28. Inhalation Exposures to 1,2-Dichloroethane for Industrial and Commercial Non-aerosol Cleaning and Degreasing Based on TCE Data as a Surrogate

Exposure Concentration Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentration	14	78	1.1	9.1

From the 8-hour TWA, EPA estimated the AC, $ADC_{intermediate}$, and ADC, LADC for non-aerosol cleaning/degreasing. These exposure metrics are presented in Table 3-29. Equations for calculating AC, $ADC_{intermediate}$, and ADC, LADC are presented in Appendix B.

Table 3-29. Summary of Worker Inhalation Exposure Metrics to 1,2-Dichloroethane for Industrial and Commercial Non-aerosol Cleaning/Degreasing Based on TCE Data as Surrogate

Exposure Concentration Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentrations	14	78	1.1	9.1
Acute exposure concentrations (AC) based on 8-hour TWA	9.4	53	0.75	6.2
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	6.9	39	0.55	4.5
Average daily concentration (ADC) based on 8-hour TWA	6.4	36	0.51	4.2
Lifetime average daily concentration (LADC) based on 8-hour TWA	2.6	19	0.20	2.2

3.8.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. EPA assessed dermal exposures using the concentration range reported in an SDS for a process cleaner, which is 99 to 100 percent (Occidental Chemical Corp, 2015).Table 3-30 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane. The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in

Appendix B.

Table 3-30. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Industrial and Commercial Non-aerosol Cleaning/Degreasing

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	3.2	5.5
	Acute retained dose (ARD) (mg/kg-day)	4.0E−02	6.9E−02
	Intermediate retained dose ($ADD_{intermediate}$), non-cancer	3.0E−02	5.1E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	2.8E−02	4.7E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	1.0E−02	2.0E−02

[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.

3.9 Industrial and Commercial Aerosol Products

EPA has identified that 1,2-dichloroethane is used as a component of cleaning and degreasing solvents within the aerospace industry (EPA-HQ-OPPT-2018-0427-0005). Additionally, EPA identified an SDS for 1,2-dichloroethane (99–100%) that identified use as a process cleaner (Occidental Chemical Corp, 2015), and another SDS for 1,2-dichloroethane (90–100%) that identified use as a general solvent (Pharmco Products, 2013 6286319). The DOE confirmed that 1,2-dichloroethane is used in the cleaning and machining of sensitive materials (DOE, 2025). As listed in Table 1-1, this OES includes the following COU: part of a Component of degreasing and cleaning solvents.

3.9.1 Worker Activities

Brake servicing models are used to represent this OES (CARB, 2000). Due to the expected similarities with Industrial and commercial aerosol products and Industrial application of lubricants and greases, the occupational exposure assessment from these two OESs utilizes the same methods.

In brake servicing, the vehicle is raised on an automobile lift to a comfortable working height to allow the worker (mechanic) to remove the wheel and access the brake system. Brake servicing can include inspections, adjustments, brake pad replacements, and rotor resurfacing. These service types often involve disassembly, replacement or repair, and reassembly of the brake system. Automotive brake cleaners are used to remove oil, grease, brake fluid, brake pad dust, or dirt. Workers may occasionally use brake cleaners, engine degreasers, carburetor cleaners, and general-purpose degreasers interchangeably (CARB, 2000). Automotive brake cleaners can come in aerosol or liquid form (CARB, 2000). EPA's use of a modeling approach combined with a high concentration of 1,2-dichloroethane in the applied product results in a conservative estimate of exposure. The Agency has uncertainty regarding the OES to be assessed for the COU.

The exposure model uses a near-field/far-field approach (AIHA, 2009), where an aerosol application located inside the near-field generates a mist of droplets, and indoor air movements lead to the convection of the droplets between the near-field and far-field. Workers are assumed to be exposed to droplet concentrations in the near-field, while ONUs are exposed at concentrations in the far-field.

3.9.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during the use of commercial aerosol products (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 334111 – Electronic Computer Manufacturing;
- 334112 – Computer Storage Device Manufacturing;
- 334118 – Computer Terminal and Other Computer Peripheral Equipment Manufacturing;
- 334412 – Bare Printed Circuit Board Manufacturing;
- 334413 – Semiconductor and Related Device Manufacturing;
- 334416 – Capacitor, Resistor, Coil, Transformer, and Other Inductor Manufacturing;
- 334417 – Electronic Connector Manufacturing;
- 334418 – Printed Circuit Assembly (Electronic Assembly) Manufacturing;
- 334419 – Other Electronic Component Manufacturing;
- 335210 – Small Electrical Appliance Manufacturing;
- 335220 – Major Household Appliance Manufacturing;
- 335910 – Battery Manufacturing;
- 335921 – Fiber Optic Cable Manufacturing;
- 335929 – Other Communication and Energy Wire Manufacturing;
- 335931 – Current-Carrying Wiring Device Manufacturing;
- 335932 – Noncurrent-Carrying Wiring Device Manufacturing;
- 335991 – Carbon and Graphite Product Manufacturing;
- 335999 – All Other Miscellaneous Electrical Equipment and Component Manufacturing;
- 336110 – Automobile and Light Duty Motor Vehicle Manufacturing;
- 336120 – Heavy Duty Truck Manufacturing;
- 336211 – Motor Vehicle Body Manufacturing;
- 336212 – Truck Trailer Manufacturing;
- 336213 – Motor Home Manufacturing;
- 336214 – Travel Trailer and Camper Manufacturing;
- 336310 – Motor Vehicle Gasoline Engine and Engine Parts Manufacturing;
- 336320 – Motor Vehicle Electrical and Electronic Equipment Manufacturing;
- 336330 – Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing;
- 336340 – Motor Vehicle Brake System Manufacturing;
- 336350 – Motor Vehicle Transmission and Power Train Parts Manufacturing;
- 336360 – Motor Vehicle Steering and Interior Trim Manufacturing;
- 336370 – Motor Vehicle Metal Stamping;
- 336390 – Other Motor Vehicle Parts Manufacturing;
- 336411 – Aircraft Manufacturing;
- 336412 – Aircraft Engine and Engine Parts Manufacturing;
- 336413 – Other Aircraft Parts and Auxiliary Equipment Manufacturing;
- 336414 – Guided Missile and Space Vehicle Manufacturing;
- 336415 – Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing;
- 336419 – Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing;
- 336611 – Ship Building and Repairing;
- 336612 – Boat Building;

- 336991 – Motorcycle, Bicycle, and Parts Manufacturing;
- 336992 – Military Armored Vehicle, Tank, and Tank Component Manufacturing;
- 366999 – All Other Transportation Equipment Manufacturing;
- 811111 – General Automotive Repair;
- 332510 – Hardware Manufacturing;
- 332912 – Fluid Power Valve and Hose Fitting Manufacturing;
- 334511 – Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing; and
- 334519 – Other Measuring and Controlling Device Manufacturing.

Table 3-31 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 1.1.

Table 3-31. Estimated Number of Workers Potentially Exposed to 1,2-Dichloroethane During Application of Commercial Aerosol Products

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
30	334111 – Electronic Computer Manufacturing	12	5
	334112 – Computer Storage Device Manufacturing		
	334118 – Computer Terminal and Other Computer Peripheral Equipment Manufacturing		
	334412 – Bare Printed Circuit Board Manufacturing		
	334413 – Semiconductor and Related Device Manufacturing		
	334416 – Capacitor, Resistor, Coil, Transformer, and Other Inductor Manufacturing		
	334417 – Electronic Connector Manufacturing		
	334418 – Printed Circuit Assembly (Electronic Assembly) Manufacturing		
	334419 – Other Electronic Component Manufacturing		
	335210 – Small Electrical Appliance Manufacturing		
	335220 – Major Household Appliance Manufacturing		
	335910 – Battery Manufacturing		
	335921 – Fiber Optic Cable Manufacturing		
	335929 – Other Communication and Energy Wire Manufacturing		
	335931 – Current-Carrying Wiring Device Manufacturing		
	335932 – Noncurrent-Carrying Wiring		

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
30	Device Manufacturing	12	5
	335991 – Carbon and Graphite Product Manufacturing		
	335999 – All Other Miscellaneous Electrical Equipment and Component Manufacturing		
	336110 – Automobile and Light Duty Motor Vehicle Manufacturing		
	336120 – Heavy Duty Truck Manufacturing		
	336211 – Motor Vehicle Body Manufacturing		
	336212 – Truck Trailer Manufacturing		
	336213 – Motor Home Manufacturing		
	336214 – Travel Trailer and Camper Manufacturing		
	336310 – Motor Vehicle Gasoline Engine and Engine Parts Manufacturing		
	336320 – Motor Vehicle Electrical and Electronic Equipment Manufacturing		
	336330 – Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing		
	336340 – Motor Vehicle Brake System Manufacturing		
	336350 – Motor Vehicle Transmission and Power Train Parts Manufacturing		
	336360 – Motor Vehicle Steering and Interior Trim Manufacturing		
	336370 – Motor Vehicle Metal Stamping		
	336390 – Other Motor Vehicle Parts Manufacturing		
	336411 – Aircraft Manufacturing		
	336412 – Aircraft Engine and Engine Parts Manufacturing		
	336413 – Other Aircraft Parts and Auxiliary Equipment Manufacturing		
	336414 – Guided Missile and Space Vehicle Manufacturing		
	336415 – Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing		
	336419 – Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing		
	336611 – Ship Building and Repairing		

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
30	336612 – Boat Building	12	5
	336991 – Motorcycle, Bicycle, and Parts Manufacturing		
	336992 – Military Armored Vehicle, Tank, and Tank Component Manufacturing		
	366999 – All Other Transportation Equipment Manufacturing		
	811111 – General Automotive Repair		
	332510 – Hardware Manufacturing		
	332912 – Fluid Power Valve and Hose Fitting Manufacturing		
	334511 – Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing		
	334519 – Other Measuring and Controlling Device Manufacturing		

[a] Number of workers and occupational non-users (ONUs) per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.9.3 Occupational Inhalation Exposure Results

EPA did not identify inhalation exposure monitoring data related to the use of 1,2-dichloroethane in commercial aerosol products. As a result, EPA estimated inhalation exposures using EPA's Aerosol Degreasing approach, as described in Section 3.7.3 and Appendix E.2, where inhalation exposures are estimated using EPA's Brake Servicing Near-Field/Far-Field Exposure Model. EPA used the brake servicing model as an analogous scenario for this OES due to the aerosol use.

This near-field/far-field approach describes a scenario where an aerosol application located inside the near-field generates a mist of droplets, and indoor air movements lead to the convection of the droplets between the near-field and far-field. Workers are assumed to be exposed to droplet concentrations in the near-field, while ONUs are exposed to concentrations in the far-field (AIHA, 2009).

Based on data from the California Air Resources Board (CARB) (2000), EPA assumes each brake job requires one 14.4-oz can of aerosol brake cleaner as described in Appendix E.2. The model determines the application rate of 1,2-dichloroethane based on its weight fraction in the aerosol product. EPA uses a uniform distribution for these weight fractions, ranging from 90 to 100 percent (Occidental Chemical Corp, 2015; Pharmco Products, 2013 6286319).

An 8-hour TWA is then estimated assuming no exposure occurs outside of the brake jobs. Appendix E.2 also describes the model equations and other input parameters used in the Monte Carlo simulation for this OES.

Table 3-32 summarizes the estimated 8-hour TWA exposure for the application of industrial and commercial aerosol products containing 1,2-dichloroethane. The high-end exposures presented are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles.

Table 3-32. Summary of Modeled Worker Inhalation Exposures to 1,2-Dichloroethane for Industrial and Commercial Aerosol Products

Exposure Concentration Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentration	46	112	30	93

From the 8-hour TWA, EPA estimated the AC, $ADC_{intermediate}$, and ADC, LADC for industrial and commercial aerosol products containing 1,2-dichloroethane. These exposure metrics are presented in Table 3-33. The high-end exposures presented in Table 3-33 are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. Equations for calculating AC, $ADC_{intermediate}$, ADC, and LADC are presented in Appendix B.

Table 3-33. Summary of Modeled Worker Inhalation Exposures to 1,2-Dichloroethane for Commercial Aerosol Products

Exposure Concentration Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	Central Tendency	High-End	Central Tendency	High-End
8-Hour TWA exposure concentrations	46	112	30	93
Acute exposure concentrations (AC) based on 8-hour TWA	31	76	21	63
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	23	56	15	46
Average daily concentration (ADC) based on 8-hour TWA	21	52	14	43
Lifetime average daily concentration (LADC) based on 8-hour TWA	8.4	27	5.6	22

3.9.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. EPA assessed dermal exposures using the concentration range reported by relevant SDSs, which is 90 to 100 percent (Occidental Chemical Corp, 2015; Pharmco Products, 2013 6286319). Table 3-34 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane. The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix B.

Table 3-34. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Commercial Aerosol Products

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	3.1	5.3
	Acute retained dose (ARD) (mg/kg-day)	3.8E−02	6.6E−02
	Intermediate retained dose, non-cancer	2.8E−02	4.8E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	2.6E−02	4.5E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	9.8E−03	1.9E−02

[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.

3.10 Commercial Laboratory Use

1,2-Dichloroethane is used as a laboratory reference standard for instrument calibration and sample preparation (EPA-HQ-OPPT-2018-0426-0026). EPA identified an SDS for 1,2-dichloroethane (>95% purity) that indicates recommended use as a laboratory chemical (Thermo Fisher, 2012). Additionally, the Agency identified multiple safety data sheets for solvent mixtures used for laboratory analysis, which contained 1,2-dichloroethane (0.1–2.5% purity) (R Corporation, 2019 6286584; Spex CertiPrep LLC, 2019; Phenova, 2018; Spex CertiPrep LLC, 2018 6284287; Cerilliant, 2012). EPA also identified multiple safety data sheets for laboratory chemicals used to manufacture substances which contained 1,2-dichloroethane (≥90–100% purity) (Ladd Research, 2018; MilliporeSigma, 2016; Polysciences Inc, 2013). It was also reported to EPA that 1,2-dichloroethane is used as a fuel additive for the purposes of combustion research in NASA facilities (EPA-HQ-OPPT-2018-0427-0041).

As listed in Table 1-1, this OES includes the following COUs: Laboratory chemical (*e.g.*, reagent), and part of Fuels and related products.

3.10.1 Worker Activities

During the use of 1,2-dichloroethane as a laboratory chemical, workers are potentially exposed to the chemical during the following activities: transferring 1,2-dichloroethane from transport containers to labware, sampling/analyses, and container/equipment cleaning. During these activities workers may be exposed via inhalation of vapor or dermal contact with 1,2-dichloroethane. According to the test order report from the Vinyl Institute, workers in laboratory areas wear the following standard PPE: fire-resistant clothing, lab coat, safety glasses, chemical splash goggles, nitrile gloves, and steel toed boots. The report also listed the following task-specific PPE: half-face dust respirator (when adding dry standards), half face respirator with organic vapor cartridges (when standards are weighed on benchtop), chemical splash goggles, face shield, and nitrile gloves (Stantec ChemRisk, 2024). Note that EPA's occupational exposure estimates do not account for the use of PPE; however, the effect of respiratory and dermal protection factors on EPA's occupational exposure estimates can be explored in the "Risk Reduction" tab in the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j). For more discussion on respiratory protection and glove protection, refer to Appendix F.

ONUs include supervisors, managers, and workers present at the laboratory site but do not directly handle 1,2-dichloroethane. Therefore, EPA expects ONUs to have lower inhalation exposures, lower vapor-through-skin uptake, and no expected dermal exposure than workers who handle 1,2-dichloroethane as a laboratory chemical.

3.10.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during its use as a laboratory chemical (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 541380 – Testing Laboratories;
- 541713 – Research and Development in the Physical, Engineering, and Life Sciences (Except Nanotechnology and Biotechnology);
- 541714 – Research and Development in Biotechnology (except Nanobiotechnology); and
- 621511 – Medical Laboratories.

Table 3-35 summarizes the per site estimates for this OES based on the methodology described, including the potential number of sites identified in Section 3.10.2 of the *Draft Environmental Release Assessment for 1,2-Dichloroethane* (U.S. EPA, 2025f).

Table 3-35. Estimated Number of Workers Potentially Exposed to 1,2-Dichloroethane During the Commercial Use as a Laboratory Chemical

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
14	541380 – Testing Laboratories	6	10
	541713– Research and Development in the Physical, Engineering, and Life Sciences (Except Nanotechnology and Biotechnology)		
	541714– Research and Development in Biotechnology (except Nanobiotechnology)		
	621511 – Medical Laboratories		

[a] Number of workers and occupational non-users (ONUs) per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.10.3 Occupational Inhalation Exposure Results

Occupational inhalation data for 1,2-dichloroethane were provided via a test order submission from the Vinyl Institute, which includes manufacturers and processors of 1,2-dichloroethane. Within this dataset for manufacturers, EPA identified 29 worker full-shift PBZ samples for laboratory technicians. These laboratory technicians conducted routine daily tasks such as preparing samples for analysis, preparing chemical solutions or standards, cleaning lab equipment and glassware, and data input, interpretation, and analysis. Disposal of gas chromatography (GC) waste was reported to occur on a weekly basis, and sample analyses varied in frequency (daily, weekly, monthly, or as needed). At one site, on a weekly basis, laboratory technicians also performed sample collection from production areas in addition to the previously described tasks. Some activities, such as the sample collection from production areas, may not occur in a commercial lab setting; however, EPA assumes that the other tasks described for laboratory technicians in a manufacturing setting would be similar to tasks performed by laboratory technicians in a commercial laboratory setting. The Agency did not identify any ONU PBZ samples. Therefore, EPA used the central tendency from workers to represent ONU exposures.

EPA also reviewed additional inhalation data provided via a test order submission, which was existing data generated during the manufacture of an herbicide (BASF, 2021). This study contained six worker personal sample data points where metadata implied laboratory work. The worker data is within the same order of magnitude as the data from the laboratory data from the Vinyl Institute test order.

From this monitoring data, EPA calculated the 50th and 95th percentile 8-hour TWA concentrations to represent a central tendency and high-end estimate of potential occupational inhalation exposures, respectively, for this scenario.

Table 3-36. Inhalation Exposures to 1,2-Dichloroethane During Commercial Laboratory Use

Worker Description	Worker Inhalation Estimates (ppm)	
	Central Tendency	High-End
Laboratory technician	4.7E−02	1.3
Occupational non-usser (ONU)	4.7E−02	

From the 8-hour TWA, EPA estimated the AC, $ADC_{intermediate}$, and ADC, LADC for the commercial laboratory use of 1,2-dichloroethane. These exposure metrics are presented in Table 3-37. Exposure metrics for the herbicide manufacturing as presented in Table 3-38 for comparison. Equations for calculating AC, $ADC_{intermediate}$, and ADC, LADC are presented in Appendix B.

Table 3-37. Summary of Worker Inhalation Exposure Metrics to 1,2-Dichloroethane for Commercial Laboratory Use

Exposure Type	Worker Inhalation Estimates	
	Central Tendency	High-End
8-Hour TWA exposure concentrations	4.7E−02	1.3
Acute exposure concentrations (AC) based on 8-hour TWA	3.2E−02	0.88
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	2.3E−02	0.65
Average daily concentration (ADC) based on 8-hour TWA	2.2E−02	0.61
Lifetime average daily concentration (LADC) based on 8-hour TWA	8.7E−03	0.3

Table 3-38. Summary of Worker Inhalation Exposure Metrics to 1,2-Dichloroethane for Commercial Laboratory Use (Herbicide Manufacturing)

Exposure Type	Worker Inhalation Estimates (ppm)	
	Central Tendency	High-End
8-Hour TWA exposure concentrations	0.11	0.12
Acute exposure concentrations (AC) based on 8-hour TWA	7.5E−02	8.2E−02
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	5.5E−02	6.0E−02
Average daily concentration (ADC) based on 8-hour TWA	5.1E−02	5.6E−02
Lifetime average daily concentration (LADC) based on 8-hour TWA	2.0E−02	2.9E−02

3.10.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. EPA assessed dermal exposures using a concentration range of 10 to 100 percent, which was derived from the relevant safety data sheets (R Corporation, 2019 6286584; Spex CertiPrep LLC, 2019; Ladd Research, 2018; Phenova, 2018; Spex CertiPrep LLC, 2018; MilliporeSigma, 2016; Polysciences Inc, 2013; Cerilliant, 2012; Thermo Fisher, 2012). Table 3-39 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane. The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix B.

Table 3-39. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Commercial Laboratory Use

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	2.2	4.5
	Acute retained dose (ARD) (mg/kg-day)	2.7E−02	5.6E−02
	Intermediate retained dose ($ADD_{intermediate}$), non-cancer	2.0E−02	4.1E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	1.7E−02	3.6E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	6.5E−03	1.5E−02

[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.

3.11 Waste Handling, Treatment, and Disposal

Each of the COUs of 1,2-dichloroethane may generate waste streams of the chemical that are collected and transported to third-party sites for disposal or treatment, and these activities are assessed under this COU. Industrial sites that treat and/or dispose onsite wastes that they themselves generate are assessed in each COU assessment (sections 3.1 through 3.10). Note, point source discharges are exempt as solid wastes under Resource Conservation and Recovery Act (RCRA). Wastes of 1,2-dichloroethane that are generated during a COU and sent to a third-party site for treatment, disposal, or recycling may include the following:

- Wastewater: 1,2-dichloroethane may be contained in wastewater discharged to POTW or other, non-public wastewater treatment works (WWTs) for treatment. Industrial wastewater containing

1,2-dichloroethane discharged to a POTW may be subject to EPA or state authorized NPDES pretreatment programs. The assessment of wastewater discharges to POTWs and non-public treatment works of 1,2-dichloroethane is included in each of the COU assessments in Section 3.1 through Section 3.10

- Solid Wastes: Solid wastes are defined under RCRA as any material that is discarded by being abandoned, inherently waste-like or recycled in certain ways (certain instances of the generation and legitimate reclamation of secondary materials are exempted as solid wastes under RCRA). Solid wastes may subsequently meet RCRA's definition of hazardous waste by either being listed as a waste at 40 CFR 261.30 to 261.35 or by meeting waste-like characteristics as defined at 40 CFR 261.20 to 261.24. Solid wastes that are hazardous wastes are regulated under the more stringent requirements of Subtitle C of RCRA, whereas non-hazardous solid wastes are regulated under the less stringent requirements of Subtitle D of RCRA.
- 1,2-Dichloroethane is a U-listed hazardous waste under code U077 under RCRA: therefore, discarded, unused pure and commercial grades of 1,2-dichloroethane are regulated as a hazardous waste under RCRA (40 CFR 261.33(f)).
- Wastes Exempted as Solid Wastes under RCRA: Certain conditions of use of 1,2-dichloroethane may generate wastes of 1,2-dichloroethane that are exempted as solid wastes under 40 CFR 261.4(a). For example, the generation and legitimate reclamation of hazardous secondary materials of 1,2-dichloroethane may be exempt as a solid waste.

2020 TRI data lists off-site transfers of 1,2-dichloroethane to land disposal, wastewater treatment, incineration, and recycling facilities. Over 95 percent of off-site transfers were sent to incineration, about 3 percent to recycling and energy recover, and less than 1 percent to wastewater treatment and landfills (U.S. EPA, 2021b).

As listed in Table 1-1, this OES includes the following COU: Disposal.

3.11.1 Worker Activities

Workers are potentially exposed to 1,2-dichloroethane via inhalation of vapors or dermal contact with liquids during the unloading and cleaning of transport containers. EPA did not find information that indicates the extent that engineering controls and worker PPE are used at facilities that handle, treat, and dispose of waste containing 1,2-dichloroethane.

ONUs for this scenario include supervisors, managers, and other employees that may be in the waste handling or treatment area. ONUs do not directly handle the chemical and are therefore expected to have lower inhalation exposures, and no dermal exposures through contact with liquids or solids, than workers that engage in tasks related to the handling or treatment of waste containing 1,2-dichloroethane.

3.11.2 Number of Workers and Occupational Non-Users

EPA used data from BLS and the SUSB specific to the OES to estimate the number of workers and ONUs per site potentially exposed to 1,2-dichloroethane during waste handling, treatment and disposal (BLS, 2023; U.S. Census Bureau, 2017). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant SOC codes within the BLS data for the identified NAICS codes. From there total number of workers can be determined. This number is divided by the number of sites identified to obtain the exposed workers per site. Appendix A includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 562211 – Hazardous Waste Treatment and Disposal;

- 562212 – Solid Waste Landfill;
- 562213 – Solid Waste Combustors and Incinerators;
- 562219 – Other Nonhazardous Waste Treatment and Disposal;
- 562910 – Remediation Services;
- 562998 – All Other Miscellaneous Waste Management Services;
- 327310 – Cement Manufacturing; and
- 221320 – Sewage Treatment Facilities.

Table 3-40 summarizes the per site estimates for this OES based on the methodology described, including the potential number of sites identified in Section 1.1.

Table 3-40. Estimated Number of Workers Potentially Exposed to 1,2-Dichloroethane During Waste Handling, Disposal, and Treatment

Potential Number of Sites	NAICS Code	Potentially Exposed Workers per Site[a]	Potentially Exposed ONUs per Site[a]
39	562211 – Hazardous Waste Treatment and Disposal	14	12
	562213 – Solid Waste Combustors and Incinerators		
	327310 – Cement Manufacturing		
146	221320 – Sewage Treatment Facilities	1	1

[a] Number of workers and ONUs per site are calculated by dividing the exposed number of workers or ONUs by the number of establishments.

3.11.3 Occupational Inhalation Exposure Results

EPA conducted separate inhalation exposure assessments for landfills and WWT (including POTW) facilities. The Agency did not assess occupational exposures during remediation of 1,2-dichloroethane. For landfills, EPA did not identify any PBZ monitoring data but did identify area data from a landfill study in Greece, which included 12 samples (Loizidou and Kapetanios, 1992). The landfill receives both municipal and industrial waste. Samples were collected at three locations at the landfill facility, two locations (8 samples total) were in the landfill area itself, and one location (4 samples) was near the landfill boundaries. Worker activity information was not provided. From these monitoring data, EPA calculated the 50th and 95th percentile 8-hour TWA concentrations to represent a central tendency and high-end estimate of potential occupational inhalation exposures, respectively, for landfill sites.

For WWT facilities, EPA identified a study at an activated sludge biological treatment plant in Finland, which included summaries statistics based on 18 PBZ samples (Lehtinen and Veijanen, 2011). Samples were collected for workers in the trash raking room where a debris removal system operates, sand separation pond where heavy particles are separated from the wastewater, and sludge dewatering area where water content is reduced from the sludge. More specific worker activities were not described. Due to the lack of discrete values, EPA used the average of the arithmetic means reported in the study to represent central tendency and the maximum value reported in the study for high-end exposure.

No PBZ samples for ONU exposures were identified for either landfills or WWT facilities. Therefore, EPA used the central tendency from workers to represent ONU exposures.

Using these 8-hour TWA exposure concentrations, EPA calculated the AC, $ADC_{intermediate}$, ADC, and

LADC as described in Appendix B. The results of these calculations are shown in Table 3-41 and Table 3-42.

Table 3-41. Inhalation Exposures of Workers to 1,2-Dichloroethane During Waste Handling, Treatment, and Disposal (Landfill)

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)
	Central Tendency	High-End	
8-Hour TWA exposure concentrations	7.8E−04	2.8E−03	7.8E−04
Acute exposure concentrations (AC) based on 8-hour TWA	5.3E−04	1.9E−03	5.3E−04
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	3.9E−04	1.4E−03	3.9E−04
Average daily concentration (ADC) based on 8-hour TWA	3.6E−04	1.3E−03	3.6E−04
Lifetime average daily concentration (LADC) based on 8-hour TWA	1.4E−04	6.6E−04	1.4E−04

Table 3-42. Inhalation Exposures of Workers to 1,2-Dichloroethane During Waste Handling, Treatment, and Disposal (POTW, Non-POTW WWT)

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)
	Central Tendency	High-End	
8-hour TWA Exposure Concentrations	8.9E−02	0.24	8.9E−02
Acute exposure concentrations (AC) based on 8-hour TWA	6.0E−02	0.16	6.0E−02
Intermediate average daily concentration ($ADC_{intermediate}$) based on 8-hour TWA	4.4E−02	0.12	4.4E−02
Average daily concentration (ADC) based on 8-hour TWA	4.1E−02	0.11	4.1E−02
Lifetime average daily concentration (LADC) based on 8-hour TWA	1.6E−02	5.6E−02	1.6E−02

3.11.4 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using a Monte Carlo simulation with 100,000 iterations. The Agency used the Dermal Exposure to Volatile Liquid Model and a fraction absorbed value of 0.3 percent. EPA assessed dermal exposures using a uniform distribution of 5 to 100 percent based on upstream concentrations. Table 3-43 summarizes the APDR, ARD, $ADD_{intermediate}$, CRD (non-cancer), and CRD (cancer) for 1,2-dichloroethane.

The high-end exposure doses are the 95th percentiles of the respective simulation output, and the central tendency exposures are the 50th percentiles. OES-specific parameters for dermal exposures are described in Appendix B.

Table 3-43. Summary of Dermal Exposure Doses to 1,2-Dichloroethane for Waste Handling, Disposal, and Treatment (Landfill and WWT)

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker[a]	Acute potential dose rate (APDR) (mg/day)	1.6	4.0
	Acute retained dose (ARD) (mg/kg-day)	1.9E−02	5.0E−02
	Intermediate retained dose ($ADD_{intermediate}$), non-cancer	1.4E−02	3.6E−02
	Chronic retained dose (CRD), non-cancer (mg/kg-day)	1.3E−02	3.4E−02
	Chronic retained dose (CRD), cancer (mg/kg-day)	4.9E−03	1.4E−02

[a] Conditions where no gloves are used, or for any glove/gauntlet use without permeation data and without employee training.

4 SUMMARY OF OCCUPATIONAL EXPOSURE ESTIMATES

Table 4-1 summarizes the occupational inhalation exposure and dermal loading results for each OES. EPA's general approach for estimating occupational exposures is explained in Section 2 and the specific basis for each estimate is discussed in the relevant subsection of Section 3. See the "Inhalation Data" and "Dermal Data" tabs in the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j) for the calculations for this table.

Table 4-1. Summary Occupational Inhalation and Dermal Exposure Results of 1,2-Dichloroethane by OES

Occupational Exposure Scenario (OES)	Worker Description	Exposure Days (day/yr)	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)		Worker Dermal Exposure Estimates (mg/day)		Sources/Notes for Inhalation Data
			Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End	
Manufacturing	Operators	250	0.48	7.3	1.4E−02	1.6	3.2	5.5	Stantec ChemRisk (2024)
	Logistics technicians	250	1.7E−02	0.24					
	Maintenance technicians	250	4.9E−02	1.60					
	Laboratory technicians	250	4.7E−02	1.30					
Manufacturing as an unintended byproduct	Operators	250	7.4E−02	0.27	4.9E−03	0.16	3.2	5.5	Stantec ChemRisk (2024)
	Logistics technicians	250	6.5E−02	1.70					
	Maintenance technicians	250	2.1E−02	0.36					
	Laboratory technicians	250	2.6E−02	7.6E−02					
Repackaging	–	250	35	45	35		3.2	5.5	NIOSH (1976)
Repackaging (modeled)	–	24–119	4.9	18	4.9		3.2	5.5	U.S. EPA (2022)
Processing as a reactant	Operators	250	1.3E−03	4.8E−03	2.1E−04	2.6E−04	3.2	5.5	Stantec ChemRisk (2024)
	Logistics technicians	250	0.17	2.3					
	Maintenance technicians	250	3.2E−03	2.1E−03					
	Laboratory technicians	250	6.9E−04	1.5E−03					
	Herbicide manufacture	250	0.19	1.4	0.19	0.23			BASF (2021)

Occupational Exposure Scenario (OES)	Worker Description	Exposure Days (day/yr)	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)		Worker Dermal Exposure Estimates (mg/day)		Sources/Notes for Inhalation Data
			Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End	
Processing into formulation, mixture, or reaction product	Herbicide manufacture	250	0.19	1.4	0.19	0.23	3.2	5.5	BASF (2021)
Industrial application of adhesives and sealants	–	250	4.6	40	0.90	1.0	3.0	5.1	(OSHA, 2017; Chrostek, 1981).
Industrial application of lubricants and greases	–	250	3.5	9.0	2.3	7.4	0.24	0.45	(AIHA, 2009)
Industrial and commercial non-aerosol cleaning/degreasing	–	250	14	78	1.1	9.1	3.2	5.5	(Barsan, 1991; Seitz and Driscoll, 1989; Daniels et al., 1988; NIOSH, 1984, 1982; Ruhe et al., 1981; Lewis, 1980; Gilles et al., 1977; Rosensteel and Lucas, 1975; NIOSH, 1973).
Commercial aerosol products (aerosol degreasing, aerosol lubricants)	–	250	46	112	30	93	3.1	5.3	(AIHA, 2009)
Commercial use as a laboratory chemical	Laboratory technicians	250	4.7E−02	1.3	4.7E−02		2.2	4.5	Stantec ChemRisk (2024)
	Herbicide manufacture	250	0.11	0.12					BASF (2021)
Distribution in commerce	Not estimated								N/A
General waste handling, treatment and disposal (landfill)	–	250	7.8E−04	7.8E−04	8.9E−02	0.24	1.6	4.0	Loizidou and Kapetanios (1992)
Waste handling, treatment and disposal (WWT)	–	250	8.9E−02	0.24	8.9E−02		1.6	4.0	Lehtinen and Veijanen (2011)

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5 WEIGHT OF SCIENTIFIC EVIDENCE CONCLUSIONS FOR OCCUPATIONAL EXPOSURES

For each OES, EPA considered the (1) assessment approach; (2) quality of the data and models; and (3) strengths, limitations, assumptions, and key sources of uncertainties in the assessment results to determine a weight of scientific evidence (WOSE) rating. EPA also considered factors that increase or decrease the strength of the evidence supporting the release estimate (*e.g.*, quality of the data/information), the applicability of the release data to the OES (*e.g.*, temporal relevance, locational relevance), and the representativeness of the estimate for the whole industry. The Agency used the descriptors of robust, moderate, slight, or indeterminant to categorize the available scientific evidence using its best professional judgment, according to the Draft Systematic Review Protocol (U.S. EPA, 2021a). For example, EPA used moderate to categorize measured release data from a limited number of sources such that there is a limited number of data points that may not cover most or all the sites within the OES. EPA used slight to describe limited information that does not sufficiently cover all sites within the OES, and for which the assumptions and uncertainties are not fully known or documented. See the Draft Systematic Review Protocol (U.S. EPA, 2021a) for additional information on weight of scientific evidence conclusions.

WOSE ratings for the occupational exposure estimates for each OES, including details on the basis EPA used to determine the rating, are provided in the sections and tables that follow.

EPA estimated occupational exposure using several sources of air monitoring data; however, the source used the most in this assessment was an inhalation exposure monitoring study submitted to the Agency by the Vinyl Institute in response to a test order (Stantec ChemRisk, 2024). These data were determined to have overall data quality ratings of high through EPA's systematic review process. Other studies used had data quality ratings of high or medium.

Number of Workers

There are several uncertainties surrounding the estimated number of workers potentially exposed to 1,2-dichloroethane, as outlined below. Most are unlikely to result in a systematic underestimate or overestimate but could result in an inaccurate estimate.

CDR data are used to estimate the number of workers associated with manufacturing. There are inherent limitations to the use of CDR data as they are reported by manufacturers and importers of 1,2-dichloroethane. Manufacturers and importers are only required to report if they manufactured or imported 1,2-dichloroethane in excess of 25,000 lb at a single site during any calendar year; as such, CDR may not capture all sites and workers associated with any given chemical.

There are also uncertainties with BLS data, which are used to estimate the number of workers for the remaining conditions of use. First, BLS' Occupational Employment Statistics employment data for each industry/occupation combination are only available at the 3-, 4-, or 5-digit NAICS level, rather than the full 6-digit NAICS level. This lack of granularity could result in an overestimate of the number of exposed workers if some 6-digit NAICS are included in the less granular BLS estimates but are not likely to use 1,2-dichloroethane for the assessed applications. EPA addressed this issue by refining the OES estimates using total employment data from the U.S. Census' SUSB. However, this approach assumes that the distribution of occupation types (SOC codes) in each 6-digit NAICS is equal to the distribution of occupation types at the parent 5-digit NAICS level. If the distribution of workers in occupations with 1,2-dichloroethane exposure differs from the overall distribution of workers in each NAICS, then this approach will result in inaccuracy.

Second, EPA's judgments about which industries (represented by NAICS codes) and occupations (represented by SOC codes) are associated with the uses assessed in this report are based on the Agency's understanding of how 1,2-dichloroethane is used in each industry. Designations of which industries and occupations have potential exposures is nevertheless subjective, and some industries/occupations with few exposures might erroneously be included, or some with exposures might erroneously be excluded. This would result in inaccuracy but would be unlikely to systematically either overestimate or underestimate the number of exposed workers.

Analysis of Exposure Monitoring Data

For several of the OESs, 1,2-dichloroethane test order monitoring data were used to estimate inhalation exposures. The primary strength of these data is the use of personal and directly applicable data, and the number of samples available for workers and ONUs. The primary limitation is that EPA assumed 250 exposure days per year based on 1,2-dichloroethane exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures.

For the two remaining OESs—Industrial and commercial non-aerosol cleaning/degreasing and Application of adhesives and sealants—monitoring data from other volatile chemicals previously assessed in EPA risk evaluations were used as surrogate. The principal limitation of the monitoring data is the uncertainty in the representativeness of the data. Where few data are available, the assessed exposure levels may not be representative of worker exposure across the entire job category or industry. This may particularly be the case when monitoring data were available for only one site, such as in the case of the Waste handling, treatment, and disposal OES. Differences in work practices and engineering controls across sites can introduce variability and limit the representativeness of monitoring data. Age of the monitoring data can also introduce uncertainty due to differences in workplace practices and equipment used at the time the monitoring data were collected compared those currently in use, such as the case of the monitoring data for the Repackaging OES and others. Therefore, older data may overestimate or underestimate exposures, depending on these differences. The effects of these uncertainties on the occupational exposure assessment are unknown, as the uncertainties may result in either overestimation or underestimation of exposures depending on the actual distribution of 1,2-dichloroethane air concentrations and the variability of work practices among different sites.

This draft TSD/assessment uses existing worker exposure monitoring data to assess exposure to 1,2-dichloroethane during several COUs. To analyze the exposure data, EPA categorized each data point as either worker or ONU. The categorizations are based on descriptions of worker job activity as provided in literature and the Agency's judgment. In general, samples for employees that are expected to have the highest exposure from direct handling of 1,2-dichloroethane are categorized as worker and samples for employees that are expected to have the lower exposure and do not directly handle 1,2-dichloroethane are categorized as ONU.

Table 5-1 summarizes EPA's overall confidence in the inhalation exposure estimates for each OES.

2350 **Table 5-1. Summary of Assumptions, Uncertainty, and Overall Confidence in Occupational Inhalation Exposure Estimates by OES**

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
Manufacturing	For this OES, EPA had inhalation monitoring data from manufacturing and processing facilities of 1,2-dichloroethane provided via a test order submission from the Vinyl Institute. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the Manufacturing OES. The primary strengths of the inhalation occupational exposure estimates for this OES include the use of personal breathing zone samples directly applicable to this OES, which are preferrable to other assessment approaches such as modeling or the use of OELs, and the high number of samples available for workers and ONUs. EPA used full-shift PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process. Another strength is that the data used from Vinyl Institute were 1,2-dichloroethane specific from multiple facilities that manufacture and process 1,2-dichloroethane; the data included 123 worker and 39 ONU full-shift (8–12 hour) PBZ samples across 5 manufacturing facilities for intentional production of 1,2-dichloeothane, and 53 worker and 6 ONU full-shift PBZ samples from 2 facilities for the unintentional production of 1,2-dichloroethane as a byproduct. EPA assumed 250 exposure days/year based on 1,2-dichloroethane exposure each working day for a typical worker schedule; There were data in the test order summary report that indicated that certain tasks are done on a daily basis, while others are done less frequently. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a robust estimate of exposures.
Repackaging	For this OES, EPA had limited inhalation monitoring data, consisting only of 2 full-shift PBZ values for workers from a monitoring study with a low data quality rating from the systematic review process due to the study's age (20+ years), lack of discrete data, and lack of description of sampling or analytical methodology. Because EPA does not expect this inhalation monitoring data to sufficiently represent all potential exposures during repackaging, EPA supplemented the assessment by modeling inhalation exposures. EPA used assumptions and values from the July 2022 Chemical Repackaging GS (U.S. EPA, 2022), having a high data quality rating from the systematic review process, to assess inhalation exposures (OECD, 2009). EPA used EPA/Office of Pollution Prevention and Toxics (OPPT) models combined with Monte Carlo modeling to estimate inhalation exposures. A strength of the Monte Carlo modeling approach is that setting the range of model input values and conducting probabilistic modeling provides a full distribution of potential exposure values which are more likely than a discrete value to capture actual exposure at sites. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Also, EPA assumed that one import container is unloaded/day for repackaging, so the number of containers unloaded/year is equal to the number of exposure days/year.

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for the repackaging assessment based on the inhalation monitoring data is slight to moderate. For ONUs, EPA did not identify data or modeling approaches applicable to estimation of ONU exposure for repackaging and used a default assumption of the central tendency from modeled workers inhalation exposures to represent ONU inhalation exposures. EPA assigns a lower confidence of slight for the ONU estimate.
Processing as reactant	For this OES, EPA had inhalation data provided via a test order submission from the Vinyl Institute, which includes manufacturers and processors of 1,2-dichloroethane. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. EPA used 1,2-dichloroethane test order inhalation data to assess inhalation exposures. The primary strength of these data is the use of personal and directly applicable data, and the number of samples available for workers and ONUs. EPA identified 48 worker and 14 ONU full-shift personal breathing zone (PBZ) samples from 2 processing facilities from this dataset to estimate inhalation exposures. EPA identified 4 additional worker full-shift PBZ samples to be included in this OES from data where the unintentional production of 1,2-dichloroethane as a byproduct occurs, after metadata suggested processing as a reactant was occurring and a review of TRI reporting confirmed. These additional data points need to be integrated into this OES. EPA also reviewed inhalation data provided via a test order submission, which was existing data generated during the manufacture of an herbicide used worldwide where the 1,2-dichloroethane is used as a processing solvent (BASF, 2021). This study contained 112 worker personal sample data points and 16 ONU personal sample data points. The range of data in this source was within the range of data from the 1,2-dichloroethane test data. The range of data in this source was within the range of data from the 1,2-dichloroethane test data. The primary limitation is that EPA assumed 250 exposure days/year based on 1,2-dichloroethane exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a robust estimate of exposures.
Processing into formulation, mixture, or reaction product	EPA used inhalation data provided via a test order submission, which was existing data generated during the manufacture of an herbicide used worldwide where the 1,2-dichloroethane is used as a processing solvent (BASF, 2021). This study contained 112 worker personal sample data points and 16 ONU personal sample data points. The ONU data confirm EPA's assumptions that ONU exposure is the central tendency of worker exposure by being the same order of magnitude. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. The primary strength of these data is the use of personal and directly applicable data. The primary limitation of the data is that it is a single site and may not be representative of all processing sites. Additionally, EPA assumed 250 exposure days/year based on 1,2-dichloroethane exposure each working day for a typical worker schedule; it is uncertain

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a moderate estimate of exposures.
Application of adhesives and sealants	For this OES, EPA did not identify inhalation exposure monitoring data related to the use of 1,2-dichloroethane in the application of adhesives and sealants. Based on available data, EPA uses surrogate data from TCE during Use of paints, coatings, adhesives, and sealants. The dataset, obtained from NIOSH HHEs as well as 3 OSHA facility inspections, contained 22 samples for workers and 2 samples for ONUs, and encompassed facilities using TCE in adhesive and coating applications. It had a medium data quality rating from the systematic review process. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. The strength of these data includes that they are PBZ and are expected to be applicable to 1,2-dichloroethane similar activities. TCE and 1,2-dichloroethane also have similar vapor pressures (73.5 mm Hg vs. 78.9 mmHg for 1,2-dichloroethane), adding to the confidence that TCE is an appropriate surrogate. The primary limitation of this assessment is that it is based on data from a different chemical, which will cause inherent uncertainties due to differences in the chemical properties and possibly handling, and EPA assumed 250 exposure days/year based on exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a moderate estimate of exposures.
Application of lubricants and greases	For this OES, EPA did not identify relevant inhalation monitoring data and used modeling to estimate occupational exposures. EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate inhalation exposures. The Monte Carlo simulation with 100,000 iterations was used to capture the range of potential input parameters. Various model parameters were derived from a CARB brake service study, having a high data quality rating from the systematic review process, and 1,2-dichloroethane concentration data from SDSs of various products. EPA considered the assessment approach, the quality of the data used in the model, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation air concentrations. A strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential exposure values is more likely than a discrete value to capture actual exposure at sites. Other strengths of this model include the use of parameters derived from applicable exposure scenarios such as the CARB brake service study, and the use of known 1,2-dichloroethane concentration data from products currently on the market. The primary limitations include the uncertainty of the representativeness of modeled air concentrations toward the true distribution of inhalation concentrations for the industries and sites covered by this scenario, as this scenario is based on the typical exposure and work patterns that occur for brake services.

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a slight to moderate estimate of exposures.
Industrial and commercial non-aerosol cleaning/ degreasing	For this OES, EPA did not identify inhalation exposure monitoring data related to the use of 1,2-dichloroethane in non-aerosol degreasers. Based on available data, EPA uses surrogate data from TCE during batch open-top vapor degreasing. The dataset, obtained from NIOSH HHEs, contained 113 samples for workers and 10 samples for ONUs, and encompassed various industries. It had a high data quality rating from the systematic review process. The strength of these data includes the number of samples, and the applicability to possible 1,2-dichloroethane activities. TCE and 1,2-dichloroethane also have a similar vapor pressure (73.5 vs. 78.9 mmHg for 1,2-dichloroethane), adding to the confidence that TCE is an appropriate surrogate. The primary limitations include: (1) the data are for a different chemical, which will cause inherent uncertainties due to differences in the chemical properties and possibly handling; and (2) EPA conservatively assesses vapor degreasing as the method of non-aerosol cleaning/degreasing with the highest exposure potential; however, EPA does not have evidence that 1,2-dichloroethane is used in vapor degreasing. Additionally, the Agency assumed 250 exposure days/year based on exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations of the air concentrations, EPA has concluded that the weight of scientific evidence provides a slight to moderate estimate of exposures.
Industrial and commercial aerosol products	For this OES, EPA did not identify relevant inhalation monitoring data and used modeling to estimate occupational exposures. Due to expected similarities in worker activity (both spray applications), the Agency used the same method used for the Application of lubricants and greases OES. EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate inhalation exposures. The Monte Carlo simulation with 100,000 iterations was used to capture the range of potential input parameters. Various model parameters were derived from a CARB brake service study, having a high data quality rating from the systematic review process, and 1,2-dichloroethane concentration data from SDSs of various products. EPA considered the assessment approach, the quality of the data used in the model, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation air concentrations. A strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential exposure values is more likely than a discrete value to capture actual exposure at sites. Other strengths of this model include the use of parameters derived from applicable exposure scenarios such as the CARB brake service study, and the use of known 1,2-dichloroethane concentration data from products currently on the market. The primary limitations include the uncertainty of the representativeness of modeled air concentrations toward the true distribution of inhalation concentrations for the industries and sites covered by this scenario, as this scenario is based on the typical exposure and work patterns that occur for brake services. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a slight estimate of exposures.

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
Laboratory use	For this OES, EPA had inhalation data provided via a test order submission from the Vinyl Institute, which included manufacturers and processors of 1,2-dichloroethane. Inhalation data from the worker description "laboratory technicians" were used as analogous in this assessment. EPA also reviewed additional inhalation data provided via a test order submission, which was existing data generated during the manufacture of an herbicide (BASF, 2021). This study contained 6 worker personal sample data points where metadata implied laboratory work. The worker data is within the same order of magnitude as the data from the laboratory data from the Vinyl Institute test order. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. EPA used inhalation data to assess inhalation exposures. The primary strength of these data is that they are PBZ and capture many tasks that are expected to occur in a commercial laboratory setting. The primary limitations include: (1) the data are for laboratory technicians in a manufacturing setting, rather than a commercial setting, and so the dataset may contain exposure from activities or environments that would not occur in a commercial setting; and (2) the lack of data for ONUs. Additionally, EPA assumed 250 exposure days/year based on 1,2-dichloroethane exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a moderate estimate of exposures. For ONUs, EPA did not identify data or modeling approaches applicable to estimation of ONU exposure for laboratory use and used a default assumption of the central tendency from the workers inhalation exposures to represent ONU inhalation exposures. EPA assigns a lower confidence of slight to moderate for the ONU estimate.
Waste handling, treatment, and disposal	***Waste Handling, Treatment, and Disposal (Landfill) Inhalation Assessment*** For this OES, EPA had limited area data (12 samples) that was used in this assessment. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. The Agency used 1,2-dichloroethane inhalation data to assess inhalation exposures, having a medium data quality rating from systematic review. The primary strength of these data is that they are directly applicable concentration data that portray the concentration of 1,2-dichloroethane in the air at 3 locations around an active landfill. The primary limitations of these data are: (1) the age of the data (samples taken in 1989 and 1990); (2) only area samples were available as opposed to PBZ air concentration data; (3) the data come from a non-U.S. facility (Greece), which may not be representative of U.S. facilities; and (4) the data are from a single landfill, which may not be representative of all landfills as pollutant concentrations surrounding a landfill can vary depending on the composition and structure of the landfill. Additionally, EPA assumed 250 exposure days/year based on 1,2-dichloroethane exposure each working day for a typical worker schedule; it is uncertain whether this captures

OES	Weight of Scientific Evidence Conclusion in Occupational Inhalation Exposure Estimates
	actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a slight estimate of exposures. For ONUs, EPA did not identify data or modeling approaches applicable to estimation of ONU exposure for disposal by landfill and used a default assumption of the central tendency from the workers inhalation exposures to represent ONU inhalation exposures. EPA has a lower confidence in the ONU estimate than the workers estimate. ***Waste Handling, Treatment, and Disposal (WWT) Inhalation Assessment*** For this OES, EPA had limited summary statistics based on PBZ monitoring data (18 samples) that were used in this assessment. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. The Agency used 1,2-dichloroethane inhalation data to assess inhalation exposures, having a high data quality rating from systematic review. The primary strength of these data is the use of directly applicable PBZ data obtained from workers at a wastewater treatment plant. The data represent exposure due to several processes that commonly occur at wastewater treatment plants. The primary limitations of these data are: (1) only summary statistics were available in the study as opposed to discrete measurements; (2) the data comes from a non-U.S. facility, which may not be representative of U.S. facilities; and (3) the data were from only one facility. Additionally, EPA assumed 250 exposure days/year based on 1,2-dichloroethane exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment provides a moderate estimate of exposures. For ONUs, EPA did not identify data or modeling approaches applicable to estimation of ONU exposure for disposal by wastewater treatment and used a default assumption of the central tendency from the workers inhalation exposures to represent ONU inhalation exposures. EPA assigns a lower confidence of slight to moderate for the ONU estimate.

EPA estimated dermal exposures using modeling methodologies, which are supported by moderate evidence. The Agency used the EPA Dermal Exposure to Volatile Liquids combined with Monte Carlo modeling to calculate the dermal retained dose. EPA used data on 1,2-dichloroethane for the fraction absorption parameter (Labcorp Early Development, 2024) and OES-specific data for the weight percent parameter in the model. A strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential exposure values is more likely than a discrete value to capture actual exposure at sites. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential dermal exposures. Therefore, the weight of scientific evidence for the modeling methodologies specifically for all OES is moderate.

Note that EPA did not assess dermal exposures to ONUs as EPA does not expect ONUs to directly handle 1,2-dichloroethane as part of their duties, and thus ONUs are not expected to have routine dermal exposures during the course of their work. Depending on the COU, ONUs may have incidental dermal exposures due to surface contamination, but EPA did not consider these exposures to be significant and thus they were not assessed.

Table 5-2 summarizes EPA's overall confidence in the dermal exposure estimates for each OES.

Table 5-2. Summary of Assumptions, Uncertainty, and Overall Confidence in Occupational Dermal Exposure Estimates by OES

OES	Weight of Scientific Evidence Conclusion in Occupational Dermal Exposure Estimates
Manufacturing	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Manufacturing OES.
Repackaging	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. EPA used assumptions and values from the July 2022 Chemical Repackaging GS (U.S. EPA, 2022), which the systematic review process rated high for data quality, to assess dermal exposures. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Repackaging OES.
Processing as reactant	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Processing as a reactant OES.
Processing into formulation, mixture, or reaction product	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Processing into formulation, mixture, or reaction product OES.
Application of adhesives and sealants	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. EPA used assumptions and values from the April 2015 ESD on the Use of Adhesives (OECD, 2015), which the systematic review process rated high for data quality, to assess dermal exposures. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Application of adhesives and sealants OES.

OES	Weight of Scientific Evidence Conclusion in Occupational Dermal Exposure Estimates
Application of lubricants and greases	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Application of lubricants and greases OES.
Industrial and commercial non-aerosol cleaning/degreasing	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Industrial and commercial non-aerosol cleaning/degreasing OES.
Industrial and commercial aerosol products	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Industrial and commercial aerosol products OES.
Laboratory use	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. EPA used assumptions and values from the 2023 Use of Laboratory Chemicals GS (U.S. EPA, 2023), which the systematic review process rated high for data quality, to assess dermal exposures. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Laboratory use OES.
Waste handling, treatment, and disposal	The exposure scenarios and exposure factors underlying the dermal assessment are supported by moderate to robust evidence. Exposure factors for occupational dermal exposure include amount of material on the skin, surface area of skin exposed, and absorption of 1,2-dichloroethane through the skin. These exposure factors were informed by literature sources, the ChemSTEER User Guide (U.S. EPA, 2015) for standard exposure parameters, and a European model, with ratings from moderate to robust. Based on these strengths and limitations, EPA concluded that the weight of scientific evidence for the dermal exposure assessment is moderate for the Waste handling, treatment, and disposal OES.

6 OCCUPATIONAL EXPOSURE ASSESSMENT CONCLUSIONS

EPA considered all reasonably available information identified through its systematic review process under TSCA (U.S. EPA, 2025l) to characterize the occupational exposure of 1,2-dichloroethane. 1,2-Dichloroethane has a total PV in the United States between 30 and 40 billion lb from the 2020 CDR reporting period and it is primarily used in the synthesis of vinyl chloride monomer (U.S. EPA, 2025k).

EPA evaluated occupational exposures for each OES, which are developed based on a set of occupational activities and conditions such that similar occupational exposures are expected from the use(s) covered under each OES. The Agency provided occupational exposure results for each OES, which are expected to be representative of the population of workers and sites for the given OES in the United States. EPA used inhalation monitoring data, including directly applicable data obtained through test orders, to evaluate acute, intermediate, and chronic exposures to workers and ONUs for 7 of the 11 OESs. Modeling was performed for four OESs where no air monitoring data were available (including the Repackaging OES that used monitoring data and modeling), and surrogate data from TCE, another chlorinated solvent with a similar vapor pressure, were used for one OES (Non-aerosol cleaning and degreasing). Dermal exposure was modeled for all OESs.

Inhalation exposures to 1,2-dichloroethane are highest during repackaging and industrial uses such as non-aerosol and aerosol cleaning, degreasing, and application of adhesives, sealants, and lubricants. Dermal exposures are estimated to be similar among most OESs, with the highest exposure occurring during the Manufacturing and Processing life cycle stages.

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APPENDICES

Appendix A ESTIMATING NUMBER OF WORKERS AND OCCUPATIONAL NON-USERS

This appendix summarizes the methods that EPA/OPPT used to estimate the number of workers who are potentially exposed to 1,2-dichloroethane in each of its COUs under TSCA. The method consists of the following steps:

1. Check relevant emission scenario documents (ESDs) and generic scenarios (GSs) for estimates on the number of workers potentially exposed.
2. Identify the NAICS codes for the industry sectors associated with each COU.
3. Estimate total employment by industry/occupation combination using the Bureau of Labor Statistics' Occupational Employment Statistics data (BLS, 2023).
4. Refine the Occupational Employment Statistics estimates where they are not sufficiently granular by using the U.S. Census' (U.S. Census Bureau, 2017) Statistics of U.S. Businesses (SUSB) data on total employment by 6-digit NAICS.
5. Estimate the percentage of employees likely to be using 1,2-dichloroethane instead of other chemicals (*i.e.*, the market penetration of 1,2-dichloroethane in the COU).
6. Estimate the number of sites and number of potentially exposed employees per site.
7. Estimate the number of potentially exposed employees within the COU.

Step 1: Identifying Affected NAICS Codes

As a first step, EPA/OPPT identified NAICS industry codes associated with each COU. EPA/OPPT generally identified NAICS industry codes for a COU by:

- Querying the U.S. Census Bureau's NAICS Search tool (U.S. Census Bureau, 2022) using keywords associated with each COU to identify NAICS codes with descriptions that match the condition of use.
- Referencing EPA/OPPT GS's and Organisation for Economic Co-operation and Development (OECD) ESDs for a COU to identify NAICS codes cited by the GS or ESD.
- Reviewing CDR data for the chemical, identifying the industrial sector codes reported for downstream industrial uses, and matching those industrial sector codes to NAICS codes using Table D-2 provided in the CDR reporting instructions (U.S. EPA, 2016).

Each COU section in the main body of this draft TSD identifies the NAICS codes EPA/OPPT identified for the respective COU.

Step 2: Estimating Total Employment by Industry and Occupation

BLS's Occupational Employment Statistics data provide employment data for workers in specific industries and occupations (BLS, 2023). The industries are classified by NAICS codes that were previously identified and occupations are classified by Standard Occupational Classification (SOC) codes (BLS, 2018).

Among the relevant NAICS codes (identified previously), EPA/OPPT reviewed the occupation description and identified those occupations (SOC codes) where workers are potentially exposed to 1,2-dichloroethane. Table_Apx A-1 shows the SOC codes by NAICS codes EPA/OPPT classified as occupations potentially exposed to 1,2-dichloroethane for an example associated with 4-digit NAICS code 221300 Water, Sewage and Other Systems. These occupations are classified as workers (W) and occupational non-users (O) by NAICS code. All relevant SOC codes by NAICS codes combinations can be found in supplemental file *Draft Estimates of Number of Workers and ONUs Model for 1,2-*

Dichloroethane (U.S. EPA, 2025g) on sheet "Affected SOCs" and all other SOC codes by NAICS codes combinations are assumed to represent occupations where exposure is unlikely.

After identifying relevant NAICS and SOC codes, EPA/OPPT used BLS data to determine total employment by industry and by occupation based on the NAICS and SOC combinations. For example, there are 1,520 employees associated with 4-digit NAICS 221300 (Water, Sewage and Other Systems) and SOC 49-9040 (Industrial Machinery Installation, Repair, and Maintenance Workers).

Using a combination of NAICS and SOC codes to estimate total employment provides more accurate estimates for the number of workers than using NAICS codes alone. Using only NAICS codes to estimate number of workers typically result in an overestimate, because not all workers employed in that industry sector will be exposed. However, in some cases, BLS only provide employment data at the 4-digit or 5-digit NAICS level; therefore, further refinement of this approach may be needed (see next step).

Step 3: Refining Employment Estimates to Account for Lack of NAICS Granularity

The third step in EPA/OPPT's methodology was to further refine the employment estimates by using total employment data in the U.S. Census Bureau's SUSB (U.S. Census Bureau, 2017). In some cases, BLS Occupational Employment Statistics' occupation-specific data are only available at the 4- or 5-digit NAICS level, whereas the SUSB data are available at the 6-digit level (but are not occupation-specific). Identifying specific 6-digit NAICS will ensure that only industries with potential 1,2-dichloroethane exposure are included. As an example, Occupational Employment Statistics data are available for the 4-digit NAICS 221300 Water, Sewage and Other Systems, which includes several 6-digit NAICS:

- NAICS 221310 Water Supply and Irrigation Systems; and
- NAICS 221320 Sewage Treatment Facilities; and
- NAICS 221330 Steam and Air-Conditioning Supply.

In this example, only NAICS 221320 Sewage Treatment Facilities is of interest. The Census data allow EPA/OPPT to calculate employment in the specific 6-digit NAICS of interest as a percentage of employment in the BLS 4-digit NAICS.

The 6-digit NAICS 221320 comprises 13.2 percent of total employment under the 4-digit NAICS 2213. This percentage can be multiplied by the occupation-specific employment estimates given in the BLS Occupational Employment Statistics data to further refine the Agency's estimates of the number of employees with potential exposure. Table_Apx A-1 illustrates this granularity adjustment for NAICS 221320.

Table_Apx A-1. Estimated Number of Potentially Exposed Workers and ONUs Under NAICS 221320

NAICS	SOC CODE	SOC Description	Occupation Designation	Employment by SOC at 4-Digit NAICS Level	% of Total Employment	Estimated Employment by SOC at 6-Digit NAICS Level
221300	11-9020	Construction Managers	O	130	13.20%	17
221300	11-9040	Architectural and Engineering Managers	O	70	13.20%	9
221300	17-2000	Engineers	O	620	13.20%	82
221300	17-3010	Drafters	O	70	13.20%	9
221300	17-3020	Engineering Technologists and Technicians, Except Drafters	O	**	**	0
221300	17-3030	Surveying and Mapping Technicians	O	**	**	0
221300	19-2031	Chemists	O	50	13.20%	7
221300	19-2041	Environmental Scientists and Specialists, Including Health	O	120	13.20%	16
221300	19-4000	Life, Physical, and Social Science Technicians	O	250	13.20%	33
221300	47-4070	Septic Tank Servicers and Sewer Pipe Cleaners	W	120	13.20%	16
221300	49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	W	1,520	13.20%	200
Total Potentially Exposed Employees				**2,950**		**389**
Total Workers						**216**
Total ONUs						**173**

W = worker; O = occupational non-user
Note: numbers may not sum exactly due to rounding. ** Not reported for this NAICS code.
Source: U.S. Census, 2017 (U.S. Census Bureau, 2017); U.S. BLS, 2023 (BLS, 2023).

Step 4: Estimating the Percentage of Workers Using 1,2-Dichloroethane Instead of Other Chemicals

In the final step, EPA/OPPT accounted for the market share by applying a factor to the number of workers determined in Step 3. This accounts for the fact that 1,2-dichloroethane may be only one of multiple chemicals used for the applications of interest. EPA/OPPT did not identify market penetration data for any COU. In the absence of market penetration data for a given COU, EPA/OPPT assumed 1,2-dichloroethane may be used at up to all sites and by up to all workers calculated in this method as a bounding estimate. This assumes a market penetration of 100 percent.

Step 5: Estimating the Number of Workers and Occupational Non-Users (ONUs) per Site

EPA/OPPT calculated the number of workers and ONUs in each industry/occupation combination using the formula below (granularity adjustment is only applicable where SOC data are not available at the 6-digit NAICS level):

Number of Workers or ONUs in NAICS/SOC (Step 2) $\times$ *Granularity Adjustment Percentage (Step 3) = Number of Workers or ONUs in the Industry/Occupation Combination*

EPA/OPPT then estimated the total number of establishments by obtaining the number of establishments reported in the U.S. Census Bureau's SUSB (U.S. Census Bureau, 2017) data at the 6-digit NAICS level. In this example, there are 652 establishments associated with 6-digit NAICS code 221320 *Sewage Treatment Facilities*.

EPA/OPPT then summed the number of workers and ONUs over all occupations within a NAICS code and divided these sums by the number of establishments in the NAICS code to calculate the average number of workers and ONUs per site.

Step 6: Estimating the Number of Workers and ONUs, and Sites for a COU

EPA/OPPT estimated the number of workers and ONUs potentially exposed to 1,2-dichloroethane and the number of sites that use 1,2-dichloroethane in a given COU through the following steps:

6.A. Obtaining the total number of establishments by:
   i. Obtaining the number of establishments from SUSB at the 6-digit NAICS level (Step 5) for each NAICS code in the COU and summing these values; or
   ii. Obtaining the number of establishments from the TRI, DMR, NEI, or literature for the COU.

6.B. Estimating the number of establishments that use 1,2-dichloroethane by taking the total number of establishments from Step 6.A and multiplying it by the market penetration factor from Step 4.

6.C. Estimating the number of workers and ONUs potentially exposed to 1,2-dichloroethane by taking the number of establishments calculated in Step 6.B and multiplying it by the average number of workers and ONUs per site from Step 5.

Appendix B EQUATIONS FOR CALCULATING ACUTE, INTERMEDIATE, AND CHRONIC (NON-CANCER AND CANCER) INHALATION AND DERMAL EXPOSURES

This report assesses 1,2-dichloroethane inhalation exposures to workers in occupational settings, presented as 8-hour (*i.e.*, full-shift) time weighted average (TWA). The full-shift TWA exposures are then used to calculate acute exposure concentrations (AC), intermediate average daily concentrations ($ADC_{intermediate}$), average daily concentrations (ADC) for chronic, non-cancer risks, lifetime average daily concentrations (LADC) for chronic, cancer risks.

This report also assesses 1,2-dichloroethane dermal exposures to workers in occupational settings, presented as a dermal acute potential dose rate (APDR). The APDRs are then used to calculate acute retained doses (AD), intermediate average daily doses ($ADD_{intermediate}$), average daily doses (ADD) for chronic non-cancer risks, and lifetime average daily doses (LADD) for chronic cancer risks.

This appendix presents the equations and input parameter values used to estimate each exposure metric.

B.1 Equations for Calculating Acute, Intermediate, and Chronic (Non-Cancer, and Cancer) Inhalation Exposures

AC is used to estimate workplace inhalation exposures for acute risks (*i.e.*, risks occurring as a result of exposure for <1 day), per Equation_Apx B-1.

Equation_Apx B-1.

$$AC = \frac{C \times ED \times BR}{AT_{acute}}$$

Where:

AC	=	Acute exposure concentration
C	=	Contaminant concentration in air (TWA)
ED	=	Exposure duration (hr/day)
BR	=	Breathing rate ratio (unitless)
AT_{acute}	=	Acute averaging time (hr)

$ADC_{intermediate}$ is used to estimate workplace exposures for intermediate risks and is estimated as follows:

Equation_Apx B-2.

$$ADC_{intermediate} = \frac{C \times ED \times EF_{intermediate} \times BR}{AT_{intermediate}}$$

Equation_Apx B-3.

$$AT_{intermediate} = D_{intermediate} \times 24 \frac{h}{day}$$

Where:

$ADC_{intermediate}$	=	Intermediate average daily concentration
$EF_{intermediate}$	=	Intermediate exposure frequency
$AT_{intermediate}$	=	Averaging time (hours) for intermediate exposure
$D_{intermediate}$	=	Days for intermediate duration (day)

ADC and LADC are used to estimate workplace exposures for non-cancer and cancer risks, respectively. These exposures are estimated as follows:

Equation_Apx B-4.

$$ADC\ or\ LADC = \frac{C \times ED \times EF \times WY \times BR}{AT\ or\ AT_c}$$

Equation_Apx B-5.

$$AT = WY \times 365\frac{day}{yr} \times 24\frac{hr}{day}$$

Equation_Apx B-6.

$$AT_C = LT \times 365\frac{day}{yr} \times 24\frac{hr}{day}$$

Where:

ADC	=	Average daily concentration used for chronic non-cancer risk calculations
LADC	=	Lifetime average daily concentration used for chronic cancer risk calculations
ED	=	Exposure duration (hours/day)
EF	=	Exposure frequency (day/yr)
WY	=	Working years/lifetime (yr)
AT	=	Averaging time (hours) for chronic, non-cancer risk
AT_C	=	Averaging time (hours) for cancer risk
LT	=	Lifetime years (yr) for cancer risk

B.2 Equations for Calculating Acute, Intermediate, and Chronic (Non-Cancer and Cancer) Dermal Exposures

AD is used to estimate workplace dermal exposures for acute risks and are calculated using Equation_Apx B-7.

Equation_Apx B-7,

$$AD = \frac{APDR}{BW}$$

Where:

AD	=	Acute retained dose (mg/kg-day)
APDR	=	Acute potential dose rate (mg/day)
BW	=	Body weight (kg)

$ADD_{intermediate}$ is used to estimate workplace dermal exposures for intermediate risks and is estimated using Equation_Apx B-8.

Equation_Apx B-8.

$$ADD_{intermediate} = \frac{APDR \times EF_{intermediate}}{BW \times D_{intermediate}}$$

Where:

$ADD_{intermediate}$	=	Intermediate average daily dose (mg/kg-day)

ADD and LADD are used to estimate workplace dermal exposures for non-cancer and cancer risks and are calculated using Equation_Apx B-9.

Equation_Apx B-9.

$$ADD\ or\ LADD = \frac{APDR \times EF \times WY}{BW \times 365\frac{days}{yr} \times (WY\ or\ LT)}$$

Where WY and LT are used in the denominator for ADD and LADD, respectively.

B.3 Acute, Intermediate, and Chronic (Non-Cancer and Cancer) Equation Inputs

The input parameter values in Table_Apx B-1 are used to calculate each of the above acute, intermediate, and chronic exposure estimates. Where exposure is calculated using probabilistic modeling, the calculations are integrated into the Monte Carlo simulation. Where multiple values are provided for ED, it indicates that EPA may have used different values for different conditions of use. The EF and $EF_{intermediate}$ used for each OES can differ and the values used are described in the appropriate sections of this report. The maximum values used in the equations as well as a general summary for these differences are described below in this section.

Table_Apx B-1. Parameter Values for Calculating Inhalation Exposure Estimates

Parameter Name	Symbol	Value	Unit
Exposure Duration	ED	8	hr/day
Breathing Rate Ratio	BR	2.04	unitless
Exposure Frequency	EF	125–350[a]	days/yr
Exposure Frequency, intermediate	$EF_{intermediate}$	22	days
Days for intermediate duration	$D_{intermediate}$	30	days
Working years	WY	31 (50th percentile) 40 (95th percentile)	years
Lifetime Years, cancer	LT	78	years
Averaging Time, intermediate	$AT_{intermediate}$	720	hr
Averaging Time, non-cancer	AT	271,560 (central tendency) [b] 350,400 (high-end) [c]	hr
Averaging Time, cancer	AT_c	683,280	hr
Body Weight	BW	80 (average adult worker) 72.4 (female of reproductive age)	kg

[a] Depending on OES
[b] Calculated using the 50th percentile value for working years (WY)
[c] Calculated using the 95th percentile value for working years (WY)

B.3.1 Exposure Duration (ED)

EPA generally uses an exposure duration of 8 hours/day for averaging full-shift exposures.

B.3.2 Breathing Rate Ratio

EPA uses a breathing rate ratio, which is the ratio between the worker breathing rate and resting breathing rate, to account for the amount of air a worker breathes during exposure. The typical worker breathes about 10 m^3 of air in 8 hours, or 1.25 m^3/h (CEB, 1991) while the resting breathing rate is 0.6125 m^3/h (CEB, 1991). The ratio of these two values is equivalent to 2.04.

B.3.3 Exposure Frequency (EF)

EPA generally uses a maximum exposure frequency of 250 days/year. The estimation of the exposure frequency and associated distributions for each OES are described in the relevant section of this report.

EF is expressed as the number of days/year a worker is exposed to the chemical being assessed. In some cases, it may be reasonable to assume a worker is exposed to the chemical on each working day. In other cases, it may be more appropriate to estimate a worker's exposure to the chemical occurs during a subset of the worker's annual working days. The relationship between exposure frequency and annual working days can be described mathematically as follows:

Equation_Apx B-10.

$$EF = f \times AWD$$

Where:

EF = Exposure frequency, the number of days/year a worker is exposed to the chemical (day/yr)

f = Fractional number of annual working days during which a worker is exposed to the chemical (unitless)

AWD = Annual working days, the number of days/year a worker works (day/yr)

BLS (2016) provides data on the total number of hours worked and total number of employees by each industry NAICS code. These data are available from the 3- to 6-digit NAICS level (where 3-digit NAICS are less granular and 6-digit NAICS are the most granular). Dividing the total, annual hours worked by the number of employees yields the average number of hours worked/employee per year for each NAICS.

EPA has identified approximately 140 NAICS codes applicable to the multiple conditions of use for the ten chemicals undergoing risk evaluation. For each NAICS code of interest, the Agency looked up the average hours worked per employee/year at the most granular NAICS level available (*i.e.*, 4-digit, 5-digit, or 6-digit). EPA converted the working hours/employee to working days/year per employee assuming employees work an average of 8 hours/day. The average number of days/year worked, or AWD, ranges from 169 to 282 days/year, with a 50th percentile value of 250 days/year. EPA repeated this analysis for all NAICS codes at the 4-digit level. The average AWD for all 4-digit NAICS codes ranges from 111 to 282 days/year, with a 50th percentile value of 228 days/ year. 250 days/year is approximately the 75th percentile. In the absence of industry- and 1,2-dichloroethane specific data, EPA assumes the parameter *f* is equal to one for all TSCA COUs.

B.3.4 Intermediate Exposure Frequency ($EF_{intermediate}$)

For 1,2-dichloroethane, the $D_{intermediate}$ was set at 30 days. EPA estimated the maximum number of working days within the $D_{intermediate}$, using the following equation and assuming 5 working days/wk:

Equation_Apx B-11.

$$EF_{intermediate}(max) = 5\,\frac{working\ days}{wk} \times \frac{30\ total\ days}{7\,\frac{total\ days}{wk}} = 21.4\ days, rounded\ up\ to\ 22\ days$$

B.3.5 Intermediate Duration ($D_{intermediate}$)

EPA assessed an intermediate duration of 30 days based on the available health data.

B.3.6 Working Years (WY)

EPA has developed a triangular distribution for working years. EPA has defined the parameters of the triangular distribution as follows:

- Minimum value: BLS Current Population Survey (CPS) tenure data with current employer as a low-end estimate of the number of lifetime working years: 10.4 years;
- Mode value: The 50th percentile tenure data with all employers from SIPP as a mode value for the number of lifetime working years: 36 years; and
- Maximum value: The maximum average tenure data with all employers from SIPP as a high-end estimate on the number of lifetime working years: 44 years.

This triangular distribution has a 50th percentile value of 31 years and a 95th percentile value of 40 years. EPA uses these values for central tendency and high-end ADC and LADC calculations, respectively.

The BLS (BLS, 2014) provides information on employee tenure with *current employer* obtained from the CPS, which is a monthly sample survey of about 60,000 households that provides information on the labor force status of the civilian non-institutional population age 16 and over. CPS data are released every 2 years. The data are available by demographics and by generic industry sectors but are not available by NAICS codes.

The U.S. Census' (U.S. Census Bureau, 2019a) Survey of Income and Program Participation (SIPP) provides information on *lifetime tenure with all employers*. SIPP is a household survey that collects data on income, labor force participation, social program participation and eligibility, and general demographic characteristics through a continuous series of national panel surveys of between 14,000 and 52,000 households (U.S. Census Bureau, 2019a). EPA analyzed the 2008 SIPP Panel Wave 1, a panel that began in 2008 and covers the interview months of September 2008 through December 2008 (U.S. Census Bureau, 2019a, b). For this panel, lifetime tenure data are available by Census Industry Codes, which can be crosswalked with NAICS codes.

SIPP data include fields for the industry in which each surveyed, employed individual works (TJBIND1), worker age (TAGE), and years of work experience *with all employers* over the surveyed individual's lifetime.[1] Census household surveys use different industry codes than the NAICS codes used in its firm surveys, so these were converted to NAICS using a published crosswalk. EPA calculated the average tenure for the following age groups: (1) workers age 50 and older, (2) workers age 60 and older, and (3) workers of all ages employed at time of survey. The Agency used tenure data for age group "50 and older" to determine the high-end lifetime working years, because the sample size in this age group is often substantially higher than the sample size for age group "60 and older." For some industries, the number of workers surveyed, or the *sample size*, was too small to provide a reliable representation of the worker tenure in that industry. Therefore, EPA excluded data where the sample size is less than five from the Agency's analysis.

Table_Apx B-2 summarizes the average tenure for workers age 50 years and older from SIPP data.

[1] To calculate the number of years of work experience EPA took the difference between the year first worked (TMAKMNYR) and the current data year (*i.e.*, 2008). The Agency then subtracted any intervening months when not working (ETIMEOFF).

Although the tenure may differ for any given industry sector, there is no significant variability between the 50th and 95th percentile values of average tenure across manufacturing and non-manufacturing sectors.

Table_Apx B-2. Overview of Average Worker Tenure from U.S. Census SIPP (Age Group 50+)

Industry Sectors	Working Years			
	Average	50th Percentile	95th Percentile	Maximum
All industry sectors relevant to the first 10 chemicals that have undergone a risk evaluation	35.9	36	39	44
Manufacturing sectors (NAICS 31–33)	35.7	36	39	40
Non-manufacturing sectors (NAICS 42–81)	36.1	36	39	44
Source: (U.S. Census Bureau, 2019a). Note: Industries where sample size is <5 are excluded from this analysis.				

BLS CPS data provides the median years of tenure that wage and salary workers had been with their current employer. Table_Apx B-3 presents CPS data for all demographics (men and women) by age group from 2008 to 2012. To estimate the low-end value on number of working years, EPA uses the most recent (2014) CPS data for workers ages 55 to 64 years, which indicates a median tenure of 10.4 years with their current employer. The use of this low-end value represents a scenario where workers are only exposed to the chemical of interest for a portion of their lifetime working years, as they may change jobs or move from one industry to another throughout their career.

Table_Apx B-3. Median Years of Tenure with Current Employer by Age Group

Age (years)	January 2008	January 2010	January 2012	January 2014
16+	4.1	4.4	4.6	4.6
16–17	0.7	0.7	0.7	0.7
18–19 years	0.8	1.0	0.8	0.8
20–24 years	1.3	1.5	1.3	1.3
25+	5.1	5.2	5.4	5.5
25–34 years	2.7	3.1	3.2	3.0
35–44 years	4.9	5.1	5.3	5.2
45–54 years	7.6	7.8	7.8	7.9
55 to 64 years	9.9	10.0	10.3	10.4
65+	10.2	9.9	10.3	10.3
Source: (U.S. Census Bureau, 2015)				

B.3.7 Lifetime Years (LT)

EPA assumes a lifetime of 78 years for all worker demographics.

B.3.8 Body Weight (BW)

EPA assumes a body weight of 80 kg for average adult workers. EPA assumed a body weight of 72.4 kg for females of reproductive age, per Chapter 8 of the *Exposure Factors Handbook* (U.S. EPA, 2011).

Appendix C SAMPLE CALCULATIONS FOR CALCULATING ACUTE AND CHRONIC (NON-CANCER AND CANCER) INHALATION EXPOSURES

Sample calculations for high-end and central tendency acute and chronic (non-cancer and cancer) exposure concentrations for one condition of use, Manufacturing, are demonstrated below. The explanation of the equations and parameters used is provided in Appendix B.

C.1 Example High-End AC, ADC, LADC, and SADC Calculations

Calculate AC_{HE}:

$$AC_{HE} = \frac{C_{HE} \times ED \times BR}{AT_{acute}}$$

$$AC_{HE} = \frac{7.3\ ppm \times 8\ hr/day \times 2.04}{24\ hr/day} = 5.0\ ppm$$

Calculate $SADC_{HE}$:

$$SADC = \frac{C_{HE} \times ED \times EF_{SC} \times BR}{AT_{sc}}$$

$$SADC_{HE} = \frac{7.3\ ppm \times 8\frac{hr}{day} \times 22\frac{days}{year} \times 2.04}{24\frac{hr}{day} \times 30\frac{days}{year}} = 3.6\ ppm$$

Calculate ADC_{HE}:

$$ADC_{HE} = \frac{C_{HE} \times ED \times EF \times WY \times BR}{AT}$$

$$ADC_{HE} = \frac{7.3\ ppm \times 8\frac{hr}{day} \times 350\frac{days}{year} \times 40\ years \times 2.04}{40\ years \times 365\frac{days}{yr} \times 24\frac{hr}{day}} = 4.8\ ppm$$

Calculate $LADC_{HE}$:

$$LADC_{HE} = \frac{C_{HE} \times ED \times EF \times WY \times BR}{AT_c}$$

$$LADC_{HE} = \frac{7.3\ ppm \times 8\frac{hr}{day} \times 350\frac{days}{year} \times 40\ years \times 2.04}{78\ years \times 365\frac{days}{year} \times 24\ hr/day} = 2.4\ ppm$$

C.2 Example Central Tendency AC, ADC, LADC, and SADC Calculations

Calculate AC_{CT}:

$$AC_{CT} = \frac{C_{CT} \times ED \times BR}{AT_{acute}}$$

$$AC_{CT} = \frac{0.48\ ppm \times 8\ hr/day \times 2.04}{24\ hr/day} = 0.33\ ppm$$

Calculate $SADC_{CT}$:

$$SADC_{CT} = \frac{C_{CT} \times ED \times EF_{SC} \times BR}{AT_{sc}}$$

$$SADC_{CT} = \frac{0.48\ ppm \times 8\frac{hr}{day} \times 22\frac{days}{year} \times 2.04}{24\frac{hr}{day} \times 30\frac{days}{year}} = 0.24\ ppm$$

Calculate ADC_{CT}:

$$ADC_{CT} = \frac{C_{CT} \times ED \times EF \times WY \times BR}{AT}$$

$$ADC_{CT} = \frac{0.48\ ppm \times 8\frac{hr}{day} \times 350\frac{days}{year} \times 31\ years \times 2.04}{31\ years \times 365\frac{days}{yr} \times 24\frac{hr}{day}} = 0.31\ ppm$$

Calculate $LADC_{CT}$:

$$LADC_{CT} = \frac{C_{CT} \times ED \times EF \times WY \times BR}{AT_c}$$

$$LADC_{CT} = \frac{0.48\ ppm \times 8\frac{hr}{day} \times 350\frac{days}{year} \times 31\ years \times 2.04}{78\ years \times 365\frac{days}{year} \times 24\ hr/day} = 0.12\ ppm$$

Appendix D DERMAL EXPOSURE ASSESSMENT METHOD

This appendix presents the modeling approach and equations to estimate occupational dermal exposures. This method was developed through review of relevant literature and consideration of existing exposure models, such as EPA/OPPT models and the European Centre for Ecotoxicology and Toxicology of Chemicals Targeted Risk Assessment (ECETOC TRA; accessed October 21, 2025).

D.1 Dermal Dose Equation

EPA used the following equation to estimate the acute potential dose rate (APDR) from occupational dermal exposures:

Equation_Apx D-1.

$$APDR = S \times Q_u \times f_{abs} \times Y_{derm} \times FT$$

Where:

S	=	Is the surface area of skin in contact with the chemical formulation (cm^2)
Q_u	=	Is the dermal load (*i.e.*, the quantity of the chemical formulation on the skin after the dermal contact event, mg/cm^2-event)
f_{abs}	=	Is the fractional absorption of the chemical formulation into the stratum corneum, accounting for evaporation of the chemical from the dermal load, Q_u (unitless, $0 \leq f_{abs} \leq 1$)
Y_{derm}	=	Is the weight fraction of the chemical of interest in the liquid (unitless, $0 \leq Y_{derm} \leq 1$); and
FT	=	Frequency of events (integer number/day).

The inputs to the dermal dose equation are described in Appendix D.2.

D.2 Model Input Parameters

Table_Apx D-1 summarizes the model parameters and their values for estimating dermal exposures. Additional explanations of EPA's selection of the inputs for each parameter are provided in the subsections after the following table.

Table_Apx D-1. Summary of Model Input Values

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Surface Area	S	cm^2	1,070	535	1,070	–	Uniform	See Appendix D.2.1
Dermal Load	Q_u	mg/cm^2-event	2.1	0.7	2.1	–	Uniform	See Appendix D.2.2
Fractional Absorption	f_{abs}	unitless	0.003	–	–	–	–	See Appendix D.2.3
Frequency of Events	FT	events/day	1	–	–	–	–	See Appendix D.2.5

D.2.1 Surface Area

EPA used an exposed skin surface area (S) for workers of 1,070 cm^2 for the upper bound based on the mean two-hand surface area for adult males ages 21 or older from Chapter 7 of EPA's *Exposure Factors Handbook* (U.S. EPA, 2011). For the lower bound, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.,* 535 cm^2 for workers).

It should be noted that while the surface area of exposed skin is derived from data for hand surface area, EPA did not assume that only the workers hands may be exposed to the chemical. Nor did EPA assume that the entirety of the hands is exposed for all activities. Rather, EPA assumed that dermal exposures occur to some portion of the hands plus some portion of other body parts (*e.g.,* arms) such that the total exposed surface area is approximately equal to the surface area of one or two hands for the central tendency and high-end exposure scenario, respectively.

D.2.2 Dermal Load

The dermal load (Q_u) is the quantity of chemical on the skin after the dermal contact event. This value represents the quantity remaining after the bulk chemical formulation has fallen from the hand that cannot be removed by wiping the skin (*e.g.,* the film that remains on the skin). To estimate the dermal load from each activity, EPA used data from references cited by EPA's September 2013 engineering policy memorandum: *Updating CEB's Method for Screening-Level Assessments of Dermal Exposure* (U.S. EPA, 2013). That memorandum provides for the following dermal exposure scenarios:

- Routine and incidental contact with liquids (*e.g.,* maintenance activities, manual cleaning of equipment, filling drums, connecting transfer lines, sampling, and bench-scale liquid transfers);
- Routine immersion in liquids (*e.g.,* handling of wet surfaces and spray painting);
- Routine contact with container surfaces (*e.g.,* handling closed or empty bags of solid materials); and
- Routine, direct handling of solids (*e.g.,* filling/dumping containers of powders/flakes/granules, weighing powder/scooping/mixing, handling wet or dried material in a filtration and drying process).

For liquids, the memorandum uses values of 0.7 to 2.1 mg/cm^2-event for routine or incidental contact with liquids and 1.3 to 10.3 mg/cm^2-event for routine immersion in liquids (U.S. EPA, 2013). EPA used the maximum from each range to estimate high-end dermal loads. The memorandum does not provide recommended values for a central tendency dermal loading estimate. Therefore, the Agency analyzed data from EPA's technical report *A Laboratory Method to Determine the Retention of Liquids on the Surface of the Hands* (U.S. EPA, 1992b) that served as the basis for the liquid dermal loads provided in the 2013 memorandum. To estimate central tendency liquid dermal loading values, EPA used the 50th percentile of the dermal loading results from the study for each type of activity (*i.e.,* routine/incidental contact and immersion). The 50th percentile was 1.7 mg/cm^2-event for routine/incidental contact with liquids and 3.8 mg/cm^2-event for routine immersion in liquids.

For 1,2-dichloroethane, EPA applied a uniform distribution of 0.7 to 2.1 mg/cm^2-event, respectively, for each OES.

D.2.3 Fractional Absorption

EPA used a fractional absorption (f_{abs}) of 0.003 based on fractional absorption data that was developed from a TSCA Section 4 test order (Labcorp Early Development, 2024).

D.2.4 Weight Fraction of Chemical

The weight fraction of 1,2-dichloroethane, Y_{derm}, refers to the concentration of 1,2-dichloroethane in the liquid formulation the worker's skin is exposed to. EPA generally assumes that this concentration will be equal to the weight fraction of 1,2-dichloroethane in the chemical products being handled within the OES.

D.2.5 Frequency of Events

The frequency of events, FT, refers to the number of dermal exposure events/day. Depending on the OES, workers may perform multiple activities throughout their shift that could potentially result in dermal exposures. Equation_Apx D-1 shows a linear relationship between FT and APDR; however, this fails to account for time between contact events. Because the chemical simultaneously evaporates from and absorbs into the skin, dermal exposure is a function of both the number of contact events/day and the time between contact events. Subsequent dermal exposure events may only meaningfully increase the dermal dose if there is sufficient time between the contact events to allow for significant evaporation/absorption of the previous exposure event. EPA did not identify information on how many contact events may occur and the time between contact events. Therefore, the Agency assumes a single contact event/day for estimating dermal exposures for all OESs.

Appendix E MODEL APPROACHES AND PARAMETERS

This appendix presents the modeling approach and model equations used in estimating occupational exposures for each of the applicable OESs. Note that though this assessment focuses only on occupational exposure, the models often include environmental release estimates as well, and these are also presented here so the entirety of the models used can be portrayed. The models were developed through review of the literature and consideration of existing EPA/OPPT models, ESDs, and/or GSs. An individual model input parameter could either have a discrete value or a distribution of values. EPA assigned statistical distributions based on reasonably available literature data. A Monte Carlo simulation (a type of stochastic simulation) was conducted to capture variability in the model input parameters. The simulation was conducted using the Latin hypercube sampling method in @Risk Industrial Edition, Version 7.0.0. The Latin hypercube sampling method generates a sample of possible values from a multi-dimensional distribution and is considered a stratified method, meaning the generated samples are representative of the probability density function (variability) defined in the model. EPA performed the model at 100,000 iterations to capture a broad range of possible input values, including values with low probability of occurrence.

EPA used the 95th and 50th percentile Monte Carlo simulation model result values for assessment. The 95th percentile value represents the high-end release amount or exposure level, whereas the 50th percentile value represents the typical release amount or exposure level. The following subsections detail the model design equations and parameters for each of the OESs.

E.1 Repackaging Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate exposures for 1,2-dichloroethane during the Repackaging OES. This approach utilizes the ESD for Transport and Storage of Chemicals (OECD, 2009) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on the ESD, EPA identified the following inhalation exposure points:

- Exposure point A: Transfer Operation Exposures from Emptying Drum;
- Exposure point B: Transfer Operation Exposure from Filling Small Containers; and
- Exposure point C: Exposures During Drum Cleaning.

Occupational exposures for 1,2-dichloroethane during repackaging are a function of 1,2-dichloroethane's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters for occupational exposures: saturation factor, container volume, air speed, ventilation rate, and mixing factor. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts and exposure concentrations for this OES.

E.1.1 Model Equations

Table_Apx E-1 provides the models and associated variables used to calculate occupational exposures for each exposure point within each iteration of the Monte Carlo simulation. EPA used these occupational exposures to develop a distribution of exposure outputs for the repackaging OES. The Agency assumed that the same worker performed each exposure activity resulting in a total exposure duration of up to 8 hours/day. The variables used to calculate each of the following exposure concentrations and durations include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters.

3152 The Monte Carlo simulation calculated an 8-hour TWA exposure concentration for each iteration using
3153 the exposure concentration and duration associated with each activity and assuming exposures outside
3154 the exposure activities were zero. EPA then selected 50th percentile and 95th percentile values to
3155 estimate the central tendency and high-end exposure concentrations, respectively.
3156

3157 **Table_Apx E-1. Models and Variables Applied for Exposure Points in the Repackaging OES**

Exposure Point	Model(s) Applied	Variables Used
Exposure point A: Transfer Operation Exposures from Emptying Drum	EPA/OPPT Mass Balance Inhalation Model with vapor generation rate from EPA/OAQPS AP-42 Loading Model	Vapor Generation Rate: $F_{1,2-DCA}$; VP; $F_{saturation\_unloading}$; $MW_{1,2-DCA}$; V_{import_cont}; R; T; $RATE_{fill\_drum}$; Q; k; Vm Exposure Duration: $RATE_{fill\_drum}$
Exposure point B: Transfer Operation Exposure from Filling Small Containers	EPA/OPPT Mass Balance Inhalation Model with vapor generation rate from EPA/OAQPS AP-42 Loading Model	Vapor Generation Rate: $F_{1,2-DCA}$; VP; $F_{saturation\_loading}$; $MW_{1,2-DCA}$; V_{small_cont}; R; T; $RATE_{fill\_smallcont}$; Q; k; Vm Exposure Duration: V_{import_cont}; V_{fill_cont}; $RATE_{fill\_drum}$
Exposure point C: Exposures During Drum Cleaning	EPA/OPPT Mass Balance Inhalation Model with vapor generation rate from EPA/OPPT Penetration Model or EPA/OPPT Mass Transfer Coefficient Model, based on air speed	Vapor Generation Rate: $F_{1,2-DCA}$; $MW_{1,2-DCA}$; VP; $RATE_{air\_speed}$; $D_{opening\_cont-cleaning}$; T; P; Q; k; Vm Exposure Duration: $RATE_{fill\_drum}$

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3159 ### E.1.2 Model Input Parameters

3160 Table_Apx E-2 summarizes the model parameters and their values for the Repackaging Monte Carlo
3161 simulation. Additional explanations of EPA's selection of the distributions for each parameter are
3162 provided after the following table.

3163 **Table_Apx E-2. Summary of Parameter Values and Distributions Used in the Repackaging Models**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Air Speed	$RATE_{air\_speed}$	cm/s	10	1.3	202.2	–	Lognormal	See Section E.1.2.5
Saturation Factor Unloading	$F_{saturation\_unloading}$	unitless	0.5	0.5	1.45	0.5	Triangular	See Section E.1.2.7
Saturation Factor Loading	$F_{saturation\_loading}$	unitless	0.5	0.5	1.45	0.5	Triangular	See Section E.1.2.7
Import Container Volume	V_{import_cont}	gal/container	20,000	10,000	20,000	20,000	Triangular	See Section E.1.2.8
Small Container Volume	V_{prod_cont}	gal/container	5	5	20	5	Triangular	See Section E.1.2.8
Number of Sites	Ns	sites	1	–	–	–	–	"What-if" scenario input
Production Volume	PV	kg/year	11,340	–	–	–	Uniform	"What-if" scenario input
Import Concentration	$F_{1,2\text{-}dichloroethane\_import}$	kg/kg	1.0	–	–	–	–	Assumed pure 1,2-dichloroethane repackaged
Temperature	T	Kelvin	298	–	–	–	–	Process parameter
Pressure	P	torr	760	–	–	–	–	Process parameter
Gas Constant	R	L*torr/(mol*K)	62.36367	–	–	–	–	Universal constant
1,2-Dichloroethane Vapor Pressure	VP	torr	78.9	–	–	–	–	Physical property
1,2-Dichloroethane Density	$\rho_{1,2\text{-}dichloroethane}$	kg/m^3	1,256.9	–	–	–	–	Physical property
1,2-Dichloroethane Molecular Weight	$MW_{1,2\text{-}dichloroethane}$	g/mol	98.96	–	–	–	–	Physical property
Fill Rate of Drum	$RATE_{fill\_drum}$	containers/h	20	–	–	–	–	See Section E.1.2.9
Fill Rate of Small Container	$RATE_{fill\_small}$	containers/h	60	–	–	–	–	See Section E.1.2.9
Diameter of Opening for Container Cleaning	$D_{opening\_cont\text{-}cleaning}$	cm	7.6	–	–	–	–	See Section E.1.2.6
Ventilation Rate	Q	ft^3/min	3,000	500	10,000	3,000	Triangular	See Section E.1.2.10
Mixing Factor	k	unitless	0.5	0.1	1	0.5	Triangular	See Section E.1.2.11

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E.1.2.1 Throughput Parameters

The facility production rate is calculated as an input value to be used in the model equations during each iteration. The facility production rate is calculated using the following equation:

Equation_Apx E-1.

$$PV_{site} = \frac{PV}{N_s}$$

Where:

PV = Production volume [kg/year]
N_s = Number of sites [sites]
PV_{site} = Facility production rate [kg/site-year]

EPA assumed that one imported container was unloaded/day, thus the number of release days in a single year is also equivalent to the number of import containers unloaded for repackaging in a single year. The equation to calculate the number of import containers is in Appendix E.1.2.2.

E.1.2.2 Number of Containers/Year

EPA assumed that facilities unloaded one imported drum in a single day for repackaging. EPA assumes 1,2-dichloroethane is imported in its pure form at 100 percent concentration. The number of import containers of 1,2-dichloroethane used by a site per year is calculated using the following equation:

Equation_Apx E-2.

$$N_{cont\_yr} = \frac{PV}{N_s * \rho_{1,1-DCA} * \left(0.00378541\ \frac{m^3}{gal}\right) * V_{import\_cont}}$$

Where:

PV = Production volume [kg/year]
ρ_{TCEP} = 1,2-Dichloroethane density [kg/m^3]
V_{import_cont} = Import container volume [gal/container]
N_s = Number of sites [sites]
N_{cont_yr} = Annual number of import containers [container/site-year]

E.1.2.3 Exposure Days/Year

EPA calculated the number of exposure days in a single year using the following equation:

Equation_Apx E-3.

$$RD = \frac{PV_{site}}{\rho_{1,2-DCA} * \left(0.00378541\ \frac{m^3}{gal}\right) * V_{import\_cont}}$$

Where:

RD = Release days or Number of import containers [days/site-yr or containers/site-yr]
$\rho_{1,2-DCA}$ = 1,2-Dichloroethane DCA density [kg/m^3]
V_{import_cont} = Import container volume [gal/container]

As described in Appendix E.1.2.2. EPA assumed that the number of import containers unloaded in a single operating day was one. Therefore, the number of release days is equivalent to the number of import containers, with a range of 24 to 119. 24 was used for central tendency calculations, and 119 was used for high-end calculations.

E.1.2.4 Operating Hours and Exposure Durations

EPA estimated operating hours and exposure durations using calculations and parameters provided by the ESD on Transport and Storage of Chemicals (OECD, 2009) and *ChemSTEER User Guide* (U.S. EPA, 2015). The operating time for release and exposure activities associated with unloading (release source 1 and 4; exposure points A and C) are calculated using the following equation:

Equation_Apx E-4.

$$Time_{RP1/RP4} = \frac{1}{RATE_{fill\_drum}}$$

Where:

$Time_{RP1/RP4}$	=	Operating time for release sources 1 and 4 [hrs/container]
$RATE_{fill\_drum}$	=	Fill rate of drum [containers/h]

For the emptying of drums, the *ChemSTEER User Guide* (U.S. EPA, 2015) indicates a drum fill rate of 20 drums/hour based on the Chemical Engineering Branch Manual for the Preparation of Engineering Assessments, Volume 1 [CEB Manual] (CEB, 1991). EPA assumed that one drum is imported and repackaged in a single operating day therefore equating the number of import containers received in a single year to the number of release days/year. For the cleaning of drums, the *ChemSTEER User Guide* (U.S. EPA, 2015) uses the same drum fill rate as emptying drums to estimate an exposure duration. EPA did not identify any other information on drum fill rates; therefore, EPA used a single deterministic value for fill rate.

The operating hours for both release source 3 and exposure point B is calculated using the following equation:

Equation_Apx E-5.

$$Time_{RP3} = \frac{V_{import\_cont}}{V_{fill\_cont} * Rate_{fill_{smallcont}} * RD}$$

Where:

$Time_{RP3}$	=	Operating time for release source 3 [hrs/site-day]
V_{import_cont}	=	Import container volume [gal/container]
V_{fill_cont}	=	Small container volume [gal/container]
$RATE_{fill\_smallcont}$	=	Fill rate of small container [containers/h]
RD	=	Release days or number of import containers [days/site-yr or containers/site-yr]

For filling small containers, see Appendix E.1.2.8 for details on the distribution of small container volume and Appendix E.1.2.9 for details on the small container fill rate. Generally, EPA calculated the duration of filling small containers using the container volume and fill rate from the *ChemSTEER User Guide* (U.S. EPA, 2015). The calculated small container fill duration was used for both the release source (operating hours rate for release source 3) and exposure point (exposure duration for exposure point B).

E.1.2.5 Air Speed

Baldwin and Maynard measured indoor air speeds across a variety of occupational settings in the United Kingdom (Baldwin and Maynard, 1998), specifically, 55 work areas were surveyed. EPA analyzed the air speed data from Baldwin and Maynard and categorized the air speed surveys into settings representative of industrial facilities and representative of commercial facilities. EPA fit separate distributions for these industrial and commercial settings and used the industrial distribution for this OES.

EPA fit a lognormal distribution for the dataset as consistent with the authors' observations that the air speed measurements within a surveyed location were lognormally distributed and the population of the mean air speeds among all surveys were lognormally distributed (Baldwin and Maynard, 1998). Because lognormal distributions are bound by zero and positive infinity, the Agency truncated the distribution at the largest observed value among all of the survey mean air speeds.

EPA fit the air speed surveys representative of industrial facilities to a lognormal distribution with the following parameter values: mean of 22.414 cm/s and standard deviation of 19.958 cm/s. In the model, the lognormal distribution is truncated at a minimum allowed value of 1.3 cm/s and a maximum allowed value of 202.2 cm/s (largest surveyed mean air speed observed in Baldwin and Maynard) to prevent the model from sampling values that approach infinity or are otherwise unrealistically small or large (Baldwin and Maynard, 1998).

Baldwin and Maynard only presented the mean air speed of each survey. The authors did not present the individual measurements within each survey. Therefore, these distributions represent a distribution of mean air speeds and not a distribution of spatially variable air speeds within a single workplace setting. However, a mean air speed (averaged over a work area) is the required input for the model. EPA converted the units to ft/min prior to use within the model equations.

E.1.2.6 Diameters of Opening

The *ChemSTEER User Guide* indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). In the simulation developed for the repackaging OES based on the ESD for Transport and Storage of Chemicals (OECD, 2009), EPA used the default diameters of vessels from the *ChemSTEER User Guide* for container cleaning.

For container cleaning activities, the *ChemSTEER User Guide* indicates a single default value of 5.08 cm (U.S. EPA, 2015). Therefore, EPA could not develop a distribution of values for this parameter and used the single value 5.08 cm from that user guide.

E.1.2.7 Saturation Factor

The Chemical Engineering Branch Manual for the Preparation of Engineering Assessments, Volume 1 [CEB Manual] indicates that during splash filling, the saturation concentration was reached or exceeded by misting with a maximum saturation factor of 1.45 (CEB, 1991). The CEB Manual indicates that saturation concentration for bottom filling was expected to be about 0.5 (CEB, 1991). The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on the lower bound, upper bound, and mode of the parameter. Because a mode was not provided for this parameter, EPA assigned a mode value of 0.5 for bottom filling as bottom filling minimizes volatilization (CEB, 1991). This value also corresponds to the typical value provided in the *ChemSTEER User Guide* for the EPA/OAQPS AP-42 Loading Model (U.S. EPA, 2015).

E.1.2.8 Container Size

The *ChemSTEER User Guide* (U.S. EPA, 2015) indicates a range of 20 to less than 100 gallons for the volume capacity of drums modeled in container-related activities, and the ESD for Transport and Storage of Chemicals (OECD, 2009) suggests nearly 80 percent of all steel drums in the United States have a capacity of 55 gallons. The underlying distribution import drum sizes is not known; therefore, EPA assigned a lower bound of 20 gallons, an upper bound of 100 gallons, and a mode of 55 gallons for the import container volume distribution.

The *ChemSTEER User Guide* (U.S. EPA, 2015) indicates a range of 5 to less than 20 gallons for the volume capacity of small containers modeled in container-related activities with 5 gallons as the default volume size. Therefore, EPA assigned a lower bound of 5 gallons, an upper bound of 20 gallons, and a mode of 5 gallons for the small container volume distribution.

E.1.2.9 Container Fill Rates

The *ChemSTEER User Guide* (U.S. EPA, 2015) provides a typical fill rate of 20 containers per hour for containers with 20 to 100 gallons of liquid and a typical fill rate of 60 containers per hour for containers with less than 20 gallons of liquid.

E.1.2.10 Ventilation Rate

The CEB Manual (CEB, 1991) indicates general ventilation rates in industry range from 500 to 10,000 ft^3/min, with a typical value of 3,000 ft^3/min. The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on an estimated lower bound, upper bound, and mode of the parameter. EPA assumed the lower and upper bound using the industry range of 500 to 10,000 ft^3/min and the mode using the 3,000 ft^3/min typical value (CEB, 1991).

E.1.2.11 Mixing Factor

The CEB Manual (CEB, 1991) indicates mixing factors may range from 0.1 to 1, with 1 representing ideal mixing. The CEB Manual references the 1988 ACGIH Ventilation Handbook, which suggests the following factors and descriptions: 0.67 to 1 for best mixing; 0.5 to 0.67 for good mixing; 0.2 to 0.5 for fair mixing; and 0.1 to 0.2 for poor mixing (CEB, 1991). The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on the defined lower and upper bound and estimated mode of the parameter. The mode for this distribution was not provided; therefore, the Agency assigned a mode value of 0.5 based on the typical value provided in the *ChemSTEER User Guide* for the EPA/OPPT Mass Balance Inhalation Model (U.S. EPA, 2015).

E.2 Aerosol Degreasing Model Approach and Parameters

This appendix presents the modeling approach and model equations used in the Aerosol Degreasing release model and Brake Servicing Near-Field/Far-Field Inhalation Exposure Model. These models were developed through review of the literature and consideration of existing EPA exposure models. The release model uses data from CARB to estimate 1,2-dichloroethane use rates; 100 percent of the sprayed 1,2-dichloroethane is expected to be released to air. The exposure model uses a near-field/far-field approach (AIHA, 2009), where an aerosol application located inside the near-field generates a mist of droplets, and indoor air movements lead to the convection of the droplets between the near-field and far-field. Workers are assumed to be exposed to droplet concentrations in the near-field, while ONUs are exposed at concentrations in the far-field.

The model uses the following parameters to estimate degreaser use rates and exposure concentrations in the near-field and far-field:

- Far-field size;
- Near-field size;
- Air exchange rate;
- Indoor air speed;
- Concentration of 1,2-dichloroethane in the aerosol formulation;
- Amount of degreaser used per brake job;
- Number of degreaser applications per brake job;
- Time duration of brake job;
- Operating hours per week; and
- Number of jobs per work shift.

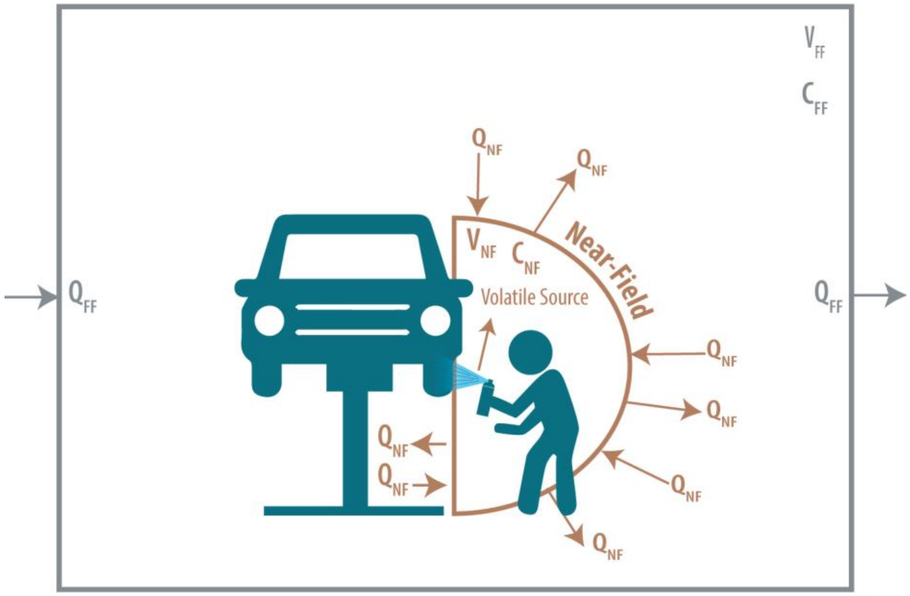
An individual model input parameter could either have a discrete value or a distribution of values. EPA assigned statistical distributions based on available literature data. A Monte Carlo simulation (a type of stochastic simulation) was conducted to capture variability in the model input parameters. The simulation was conducted using the Latin hypercube sampling method in @Risk Industrial Edition, Version 7.0.0. The Latin hypercube sampling method is a statistical method for generating a sample of possible values from a multi-dimensional distribution. Latin hypercube sampling is a stratified method, meaning it guarantees that its generated samples are representative of the probability density function (variability) defined in the model. EPA performed the model at 100,000 iterations to capture the range of possible input values (*i.e.*, including values with low probability of occurrence).

Model results from the Monte Carlo simulation are presented as 95th and 50th percentile values. The statistics were calculated directly in @Risk. The 95th percentile value was selected to represent high-end exposure level, whereas the 50th percentile value was selected to represent central tendency exposure level. The following subsections detail the model design equations and parameters for the brake servicing model.

E.2.1 Model Design Equations

In brake servicing, the vehicle is raised on an automobile lift to a comfortable working height to allow the worker (mechanic) to remove the wheel and access the brake system. Brake servicing can include inspections, adjustments, brake pad replacements, and rotor resurfacing. These service types often involve disassembly, replacement or repair, and reassembly of the brake system. Automotive brake cleaners are used to remove oil, grease, brake fluid, brake pad dust, or dirt. Mechanics may occasionally use brake cleaners, engine degreasers, carburetor cleaners, and general purpose degreasers interchangeably (CARB, 2000). Automotive brake cleaners can come in aerosol or liquid form (CARB, 2000): this model estimates exposures from aerosol brake cleaners (degreasers).

Figure_Apx E-1 illustrates the near-field/far-field modeling approach as it was applied by EPA to brake servicing using an aerosol degreaser. The application of the aerosol degreaser immediately generates a mist of droplets in the near-field, resulting in worker exposures at a concentration C_{NF}. The concentration is directly proportional to the amount of aerosol degreaser applied by the worker, who is standing in the near-field-zone (*i.e.*, the working zone). The volume of this zone is denoted by V_{NF}. The ventilation rate for the near-field zone (Q_{NF}) determines how quickly the chemical dissipates into the far-field (*i.e.*, the facility space surrounding the near-field), resulting in occupational bystander exposures to the chemical at a concentration C_{FF}. V_{FF} denotes the volume of the far-field space into which the chemical dissipates out of the near-field. The ventilation rate for the surroundings, denoted by Q_{FF}, determines how quickly the chemical dissipates out of the surrounding space and into the outside air.



Figure_Apx E-1. The Near-Field/Far-Field Model as Applied to the Brake Servicing Near-Field/Far-Field Inhalation Exposure Model

In brake servicing using an aerosol degreaser, aerosol degreaser droplets enter the near-field in non-steady "bursts," where each burst results in a sudden rise in the near-field concentration. The near-field and far-field concentrations then decay with time until the next burst causes a new rise in near-field concentration. Based on site data from automotive maintenance and repair shops obtained by CARB (2000) for brake cleaning activities and as explained in Appendices E.2.2.9 and E.2.2.12 below, the model assumes a worker will perform an average of 11 applications of the degreaser product per brake job with 5 minutes between each application and that a worker may perform 1 to 4 brake jobs per day each taking 1 hour to complete. EPA modeled two scenarios: one where the brake jobs occurred back-to-back and one where brake jobs occurred 1 hour apart. In both scenarios, EPA assumed the worker does not perform a brake job, and does not use the aerosol degreaser, during the first hour of the day.

EPA denoted the top of each 5-minute period for each hour of the day (*e.g.*, 8:00 a.m., 8:05 a.m., 8:10 a.m., etc.) as $t_{m,n}$. Here, m has the values of 0, 1, 2, 3, 4, 5, 6, and 7 to indicate the top of each hour of the day (*e.g.*, 8 a.m., 9 a.m., etc.) and n has the values of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 to indicate the top of each 5-minute period within the hour. No aerosol degreaser is used, and no exposures occur, during the first hour of the day, $t_{0,0}$ to $t_{0,11}$ (*e.g.*, 8–9 a.m.). Then, in both scenarios, the worker begins the first brake job during the second hour, $t_{1,0}$ (*e.g.*, 9–10 a.m.). The worker applies the aerosol degreaser at the top of the second 5-minute period and each subsequent 5-minute period during the hour-long brake job (*e.g.*, 9:05 a.m., 9:10 a.m.,…9:55 a.m.). In the first scenario, the brake jobs are performed back-to-back, if performing more than one brake job on the given day. Therefore, the second brake job begins at the top of the third hour (*e.g.*, 10 a.m.), and the worker applies the aerosol degreaser at the top of the second 5-minute period and each subsequent 5-minute period (*e.g.*, 10:05 a.m., 10:10 a.m.,…10:55 a.m.). In the second scenario, the brake jobs are performed every other hour, if performing more than one brake job on the given day. Therefore, the second brake job begins at the top of the fourth hour (*e.g.*, 11 a.m.), and the worker applies the aerosol degreaser at the top of the second 5-minute period and each subsequent 5-minute period (*e.g.*, 11:05 a.m., 11:10 a.m.,…11:55 a.m.).

In the first scenario, after the worker performs the last brake job, the workers and ONUs continue to be exposed as the airborne concentrations decay during the final three to six hours until the end of the day (*e.g.*, 4 p.m.). In the second scenario, after the worker performs each brake job, the workers and ONUs continue to be exposed as the airborne concentrations decay during the time in which no brake jobs are occurring and then again when the next brake job is initiated. In both scenarios, the workers and ONUs are no longer exposed once they leave work.

Based on data from CARB (2000), EPA assumes each brake job requires one 14.4-oz can of aerosol brake cleaner as described in further detail below. The model determines the application rate of 1,2-dichloroethane using the weight fraction of 1,2-dichloroethane in the aerosol product. EPA uses a uniform distribution of weight fractions for 1,2-dichloroethane based on facility data for the aerosol products in use (CARB, 2000).

The model design equations are presented below in Equation_Apx E-6 through Equation_Apx E-26.

Equation_Apx E-6. Near-Field Mass Balance

$$V_{NF}\frac{dC_{NF}}{dt} = C_{FF}Q_{NF} - C_{NF}Q_{NF}$$

Equation_Apx E-7. Far-Field Mass Balance

$$V_{FF}\frac{dC_{FF}}{dt} = C_{NF}Q_{NF} - C_{FF}Q_{NF} - C_{FF}Q_{FF}$$

Where:

V_{NF}	=	Near-field volume
V_{FF}	=	Far-field volume
Q_{NF}	=	Near-field ventilation rate
Q_{FF}	=	Far-field ventilation rate
C_{NF}	=	Average near-field concentration
C_{FF}	=	Average far-field concentration
t	=	Elapsed time

Solving Equation_Apx E-6 and
Equation_Apx E-7 in terms of the time-varying concentrations in the near-field and far-field yields Equation_Apx E-8 and Equation_Apx E-9 which EPA applied to each of the 12 5-minute increments during each hour of the day. For each 5-minute increment, EPA calculated the initial near-field concentration at the top of the period ($t_{m,n}$), accounting for both the burst of 1,2-dichloroethane from the degreaser application (if the 5-minute increment is during a brake job) and the residual near-field concentration remaining after the previous 5-minute increment ($t_{m,n-1}$; except during the first hour and $t_{m,0}$ of the first brake job, in which case there would be no residual 1,2-dichloroethane from a previous application).

The initial far-field concentration is equal to the residual far-field concentration remaining after the previous 5-minute increment. EPA then calculated the decayed concentration in the near-field and far-field at the end of the 5-minute period, just before the degreaser application at the top of the next period ($t_{m,n+1}$). EPA then calculated a 5-minute TWA exposure for the near-field and far-field, representative of the worker's and ONUs' exposures to the airborne concentrations during each 5-minute increment using Equation_Apx E-8 and Equation_Apx E-9. The *k* coefficients Equation_Apx E-10 through Equation_Apx E-13 are a function of the initial near-field and far-field concentrations, and therefore are re-calculated at the top of each 5-minute period. In the equations below, where the subscript "m, n−1" is used, if the value of n−1 is less than zero, the value at "m−1, 11" is used and where the subscript "m, n+1" is used, if the value of n+1 is greater than 11, the value at "m+1, 0" is used.

Equation_Apx E-8.

$$C_{NF,t_{m,n+1}} = \left(k_{1,t_{m,n}} e^{\lambda_1 t} + k_{2,t_{m,n}} e^{\lambda_2 t}\right)$$

Equation_Apx E-9.

$$C_{FF,t_{m,n+1}} = \left(k_{3,t_{m,n}} e^{\lambda_1 t} - k_{4,t_{m,n}} e^{\lambda_2 t}\right)$$

Where:
Equation_Apx E-10.

$$k_{1,t_{m,n}} = \frac{Q_{NF}\left(C_{FF,0}(t_{m,n}) - C_{NF,0}(t_{m,n})\right) - \lambda_2 V_{NF} C_{NF,0}(t_{m,n})}{V_{NF}(\lambda_1 - \lambda_2)}$$

Equation_Apx E-11.

$$k_{2,t_{m,n}} = \frac{Q_{NF}\left(C_{NF,0}(t_{m,n}) - C_{FF,0}(t_{m,n})\right) + \lambda_1 V_{NF} C_{NF,0}(t_{m,n})}{V_{NF}(\lambda_1 - \lambda_2)}$$

Equation_Apx E-12.

$$k_{3,t_{m,n}} = \frac{(Q_{NF} + \lambda_1 V_{NF})(Q_{NF}\left(C_{FF,0}(t_{m,n}) - C_{NF,0}(t_{m,n})\right) - \lambda_2 V_{NF} C_{NF,0}(t_{m,n}))}{Q_{NF} V_{NF}(\lambda_1 - \lambda_2)}$$

Equation_Apx E-13.

$$k_{4,t_{m,n}} = \frac{(Q_{NF} + \lambda_2 V_{NF})(Q_{NF}\left(C_{NF,0}(t_{m,n}) - C_{FF,0}(t_{m,n})\right) + \lambda_1 V_{NF} C_{NF,0}(t_{m,n}))}{Q_{NF} V_{NF}(\lambda_1 - \lambda_2)}$$

Equation_Apx E-14.

$$\lambda_1 = 0.5\left[-\left(\frac{Q_{NF}V_{FF} + V_{NF}(Q_{NF} + Q_{FF})}{V_{NF}V_{FF}}\right) + \sqrt{\left(\frac{Q_{NF}V_{FF} + V_{NF}(Q_{NF} + Q_{FF})}{V_{NF}V_{FF}}\right)^2 - 4\left(\frac{Q_{NF}Q_{FF}}{V_{NF}V_{FF}}\right)}\right]$$

Equation_Apx E-15.

$$\lambda_2 = 0.5\left[-\left(\frac{Q_{NF}V_{FF} + V_{NF}(Q_{NF} + Q_{FF})}{V_{NF}V_{FF}}\right) - \sqrt{\left(\frac{Q_{NF}V_{FF} + V_{NF}(Q_{NF} + Q_{FF})}{V_{NF}V_{FF}}\right)^2 - 4\left(\frac{Q_{NF}Q_{FF}}{V_{NF}V_{FF}}\right)}\right]$$

Equation_Apx E-16.

$$C_{NF,o}(t_{m,n}) = \begin{cases} 0, \ m = 0 \\ \frac{Amt}{V_{NF}}\left(1{,}000\frac{mg}{g}\right) + C_{NF}(t_{m,n-1}), \ n > 0 \; for\ all\ m\ where\ brake\ job\ occurs \end{cases}$$

Equation_Apx E-17.

$$C_{FF,o}(t_{m,n}) = \begin{cases} 0, \ m = 0 \\ C_{FF}(t_{m,n-1}), \ for\ all\ n\ where\ m > 0 \end{cases}$$

Equation_Apx E-18.

$$C_{NF,\text{ 5-min TWA, t}_{m,n}} = \frac{\left(\frac{k_{1,t_{m,n-1}}}{\lambda_1}e^{\lambda_1 t_2} + \frac{k_{2,t_{m,n-1}}}{\lambda_2}e^{\lambda_2 t_2}\right) - \left(\frac{k_{1,t_{m,n-1}}}{\lambda_1}e^{\lambda_1 t_1} + \frac{k_{2,t_{m,n-1}}}{\lambda_2}e^{\lambda_2 t_1}\right)}{t_2 - t_1}$$

Equation_Apx E-19.

$$C_{FF,\text{ 5-min TWA, t}_{m,n}} = \frac{\left(\frac{k_{3,t_{m,n-1}}}{\lambda_1}e^{\lambda_1 t_2} + \frac{k_{4,t_{m,n-1}}}{\lambda_2}e^{\lambda_2 t_2}\right) - \left(\frac{k_{3,t_{m,n-1}}}{\lambda_1}e^{\lambda_1 t_1} + \frac{k_{4,t_{m,n-1}}}{\lambda_2}e^{\lambda_2 t_1}\right)}{t_2 - t_1}$$

After calculating all near-field/far-field 5-minute TWA exposures (*i.e.*, $C_{NF,\text{ 5-min TWA, t}_{m,n}}$ and $C_{FF,\text{ 5-min TWA, t}_{m,n}}$) for each 5-minute (0.0833-hour) period of the work day, EPA calculated the near-field/far-field 8-hour TWA concentration and 1-hour TWA concentrations following the equations:

Equation_Apx E-20.

$$C_{NF,\text{ 8-hr }TWA} = \frac{\sum_{m=0}^{7}\sum_{n=0}^{11}\left[C_{NF,\text{5-min }TWA,t_{m,n}} \times 0.0833\ hr\right]}{8\ hr}$$

Equation_Apx E-21.

$$C_{NF,\text{ 8-hr }TWA} = \frac{\sum_{m=0}^{7}\sum_{n=0}^{11}\left[C_{FF,\text{5-min }TWA,t_{m,n}} \times 0.0833\ hr\right]}{8\ hr}$$

Equation_Apx E-22.

$$C_{NF,\text{1-hr }TWA} = \frac{\sum_{n=0}^{11}\left[C_{NF,\text{5-min }TWA,t_{m,n}} \times 0.0833\ hr\right]}{1\ hr}$$

Equation_Apx E-23.

$$C_{FF,\text{1-hr }TWA} = \frac{\sum_{n=0}^{11}\left[C_{FF,\text{5-min }TWA,t_{m,n}} \times 0.0833\ hr\right]}{1\ hr}$$

EPA calculated rolling 1-hour TWA's throughout the work day and the model reports the maximum calculated 1-hour TWA.

To calculate the mass transfer to and from the near-field, the free surface area (FSA) is defined to be the surface area through which mass transfer can occur. The FSA is not equal to the surface area of the entire near-field. EPA defined the near-field zone to be a hemisphere with its major axis oriented vertically, against the vehicle, and aligned through the center of the wheel (see Figure_Apx E-1). The top half of the circular cross-section rests against, and is blocked by, the vehicle and is not available for mass transfer. The FSA is calculated as the entire surface area of the hemisphere's curved surface and half of the hemisphere's circular surface per Equation_Apx E-24 below:

Equation_Apx E-24.

$$FSA = \left(\frac{1}{2} \times 4\pi R_{NF}^2\right) + \left(\frac{1}{2} \times \pi R_{NF}^2\right)$$

Where R_{NF} is the radius of the near-field.

The near-field ventilation rate, Q_{NF}, is calculated in Equation_Apx E-25 from the indoor wind speed, v_{NF}, and FSA, assuming half of the FSA is available for mass transfer into the near-field and half of the FSA is available for mass transfer out of the near-field:

Equation_Apx E-25.

$$Q_{NF} = \frac{1}{2} v_{NF} FSA$$

The far-field volume, V_{FF}, and the air exchange rate, AER, is used to calculate the far-field ventilation rate, Q_{FF}, as given by Equation_Apx E-26:

Equation_Apx E-26.

$$Q_{FF} = V_{FF} AER$$

Using the model inputs described in Appendix E.2.2, EPA estimated 1,2-dichloroethane inhalation exposures for workers in the near-field and for occupational non-users in the far-field. EPA then conducted the Monte Carlo simulations using @Risk (Version 7.0.0). The simulations applied 100,000 iterations and the Latin Hypercube sampling method.

E.2.2 Model Parameters

Table_Apx E-3 summarizes the model parameters and their values for the Brake Servicing Near-Field/Far-Field Inhalation Exposure Model. Each parameter is discussed in detail in the following subsections.

The specificity of more complex distributions (*e.g.*, triangular, lognormal) to characterize a model parameter value requires adequate data to demonstrate the distribution; if only an overall range is known, then a uniform distribution is the only possible distribution to use. There may be cases where a uniform distribution is appropriate if data indicate it as such, but generally, uniform distributions were used because no data were found to demonstrate a more sophisticated distribution.

Model parameters kept as constants were generally cases where data to describe variability or uncertainty of the parameter value were unknown. Additionally, some model parameters were kept as constants by choice (*i.e.*, temperature and pressure are constant as the model is isothermal and isobaric), and some were kept as constants appropriately (*i.e.*, molecular weight kept appropriately constant).

Table_Apx E-3. Summary of Parameter Values and Distributions Used in the Brake Servicing Near-Field/Far-Field Inhalation Exposure Model

Input Parameter	Symbol	Unit	Constant Model Parameter Values		Variable Model Parameter Values				Comments
			Value	Basis	Lower Bound	Upper Bound	Mode	Distribution Type	
Far-field volume	V_{FF}	m^3	141.6	–	–	–	–	Constant Value	Constant.
Air exchange rate	AER	h^{-1}	3.5	–	1	20	3.5	Triangular	Demou et al. (2009) identifies typical AERs of 1 hr^{-1} and 3–20 hr^{-1} for occupational settings with and without mechanical ventilation systems, respectively. Hellweg et al. (2009) identifies average AERs for occupational settings utilizing mechanical ventilation systems to be between 3–20 hr^{-1}. Golsteijn et al. (2014) indicates a characteristic AER of 4 hr^{-1}. Peer reviewers of EPA's 2013 TCE draft risk assessment commented that values around 2–5 hr^{-1} may be more likely (SCG, 2013), in agreement with Golsteijn et al. (2014). A triangular distribution is used with the mode equal to the midpoint of the range provided by the peer reviewer (3.5 is the midpoint of the range 2–5 hr^{-1}).
Near-field indoor wind speed	v_{NF}	ft/h	1,037	–	–	–	–	Lognormal	Lognormal distribution fit to commercial-type workplace data from Baldwin and Maynard (1998). Mean of 10.853 cm/s and standard deviation of 7.883 cm/s.
		cm/s	8.78	–	–	–	–	Lognormal	
Near-field radius	R_{NF}	m	1.5	–	–	–	–	Constant Value	Constant.
Starting time for each application period	t_1	hr	0	–	–	–	–	Constant Value	Constant.
End time for each application period	t_2	hr	0.0833	–	–	–	–	Constant Value	Assumes aerosol degreaser is applied in 5-minute increments during brake job.
Averaging Time	t_{avg}	hr	8	–	–	–	–	Constant Value	Constant.

Input Parameter	Symbol	Unit	Constant Model Parameter Values		Variable Model Parameter Values				Comments
			Value	Basis	Lower Bound	Upper Bound	Mode	Distribution Type	
1,2-dichloroethane weight fraction	wtfrac	wt frac	–	–	0.90	1	–	Discrete	Discrete distribution of 1,2-dichloroethane-based aerosol product formulations based on products identified in SDS. Where the weight fraction of 1,2-dichloroethane in the formulation was given as a range, EPA assumed a uniform distribution within the reported range for the 1,2-dichloroethane concentration in the product. See Section E.2.2.7 for further discussion.
Degreaser Used per Brake Job	W_d	oz/ job	14.4	–	–	–	–	Constant Value	Based on data from CARB (2000).
Number of Applications per Job	N_A	Applications/ job	11	–	–	–	–	Constant Value	Calculated from the average of the number of applications per brake and number of brakes per job.
Amount Used per Application	Amt	g 1,2-dichloroethane/ application	–	–	33.4	37.1	–	Calculated	Calculated from wtfrac, W_d, and N_A.
Operating hours per week	OHpW	hr/week	56.82	–	40	82.5	–	Lognormal	Lognormal distribution fit to the operating hours per week observed in CARB (2000) site visits.
Number of Brake Jobs per Work Shift	N_J	jobs/site-shift	–	–	1	4	–	Calculated	Calculated from the average number of brake jobs per site per year, OHpW, and assuming 52 operating weeks per year and 8 hours per work shift.

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E.2.2.1 Far-Field Volume

The far-field volume is based on information obtained from CARB (2000) from site visits of 137 automotive maintenance and repair shops in California. CARB (2000) indicated that shop volumes at the visited sites ranged from 200 to 70,679 m^3 with an average shop volume of 3,769 m^3. Based on these data EPA assumed a triangular distribution bound from 200 to 70,679 m^3 with a mode of 3,769 m^3 (the average of the data from CARB (2000). EPA assumed a constant room size of 141 m^3.

E.2.2.2 Air Exchange Rate

The air exchange rate (AER) is based on data from Demou et al. (2009), Hellweg et al. (2009), Golsteijn et al. (2014), and information received from a peer reviewer during the development of the 2014 TSCA Work Plan Chemical Risk Assessment Trichloroethylene: Degreasing, Spot Cleaning and Arts & Crafts Uses (SCG, 2013). Demou et al. (2009) identifies typical AERs of 1 $hour^{-1}$ and 3 to 20 $hour^{-1}$ for occupational settings with and without mechanical ventilation systems, respectively. Similarly, Hellweg et al. (2009) identifies average AERs for occupational settings using mechanical ventilation systems to vary from 3 to 20 $hour^{-1}$. Golsteijn et al. (2014) indicates a characteristic AER of 4 $hour^{-1}$. The risk assessment peer reviewer comments indicated that values around 2 to 5 $hour^{-1}$ are likely (SCG, 2013), in agreement with Golsteijn et al. (2014) and the low end reported by Demou et al. (2009) and Hellweg et al. (2009). Therefore, EPA used a triangular distribution with the mode equal to 3.5 $hour^{-1}$, the midpoint of the range provided by the risk assessment peer reviewer (3.5 is the midpoint of the range 2 to 5 $hour^{-1}$), with a minimum of 1 $hour^{-1}$, per Demou et al. (2009) and a maximum of 20 $hour^{-1}$ per Demou et al. (2009) and Hellweg et al. (2009).

E.2.2.3 Near-Field Indoor Air Speed

Baldwin and Maynard (1998) measured indoor air speeds across a variety of occupational settings in the United Kingdom. Fifty-five work areas were surveyed across a variety of workplaces.

EPA analyzed the air speed data from Baldwin and Maynard (1998) and categorized the air speed surveys into settings representative of industrial facilities and representative of commercial facilities. The Agency fit separate distributions for these industrial and commercial settings and used the commercial distribution for dry cleaners (including other textile cleaning facilities that conduct spot cleaning).

EPA fit a lognormal distribution for both datasets as consistent with the authors observations that the air speed measurements within a surveyed location were lognormally distributed and the population of the mean air speeds among all surveys were lognormally distributed. Because lognormal distributions are bound by zero and positive infinity, the Agency truncated the distribution at the largest observed value among all of the survey mean air speeds from Baldwin and Maynard (1998).

EPA fit the air speed surveys representative of commercial facilities to a lognormal distribution with the following parameter values: mean of 10.853 cm/s and standard deviation of 7.883 cm/s. In the model, the lognormal distribution is truncated at a maximum allowed value of 202.2 cm/s (largest surveyed mean air speed observed in Baldwin and Maynard (1998) to prevent the model from sampling values that approach infinity or are otherwise unrealistically large.

Baldwin and Maynard (1998) only presented the mean air speed of each survey. The authors did not present the individual measurements within each survey. Therefore, these distributions represent a distribution of mean air speeds and not a distribution of spatially-variable air speeds within a single workplace setting. However, a mean air speed (averaged over a work area) is the required input for the model.

E.2.2.4 Near-Field Volume

EPA defined the near-field zone to be a hemisphere with its major axis oriented vertically, against the vehicle, and aligned through the center of the wheel (see Figure_Apx E-1). The near-field volume is calculated per Equation_Apx E-27. EPA defined a near-field radius (R_{NF}) of 1.5 meters, approximately 4.9 feet, as an estimate of the working height of the wheel, as measured from the floor to the center of the wheel.

Equation_Apx E-27.

$$V_{NF} = \frac{1}{2} \times \frac{4}{3} \pi R_{NF}^3$$

E.2.2.5 Application Time

EPA assumed an average of 11 brake cleaner applications per brake job (see Section E.2.2.9). CARB observed, from their site visits, that the visited facilities did not perform more than one brake job in any given hour (CARB, 2000). Therefore, EPA assumed a brake job takes 1 hour to perform. Using an assumed average of 11 brake cleaner applications per brake job and 1 hour to perform a brake job, EPA calculates an average brake cleaner application frequency of once every 5 minutes (0.0833 hr). EPA models an average brake job of having no brake cleaner application during its first five minutes and then one brake cleaner application per each subsequent 5-minute period during the 1-hour brake job.

E.2.2.6 Averaging Time

EPA was interested in estimating 8-hour TWAs for use in risk calculations; therefore, a constant averaging time of 8 hours was used.

E.2.2.7 1,2-Dichloroethane Weight Fraction

EPA used a two-dimensional sampling technique to model the 1,2-dichloroethane weight fraction. A discrete distribution is used to model the frequency of occurrence of each product type. For each product, the concentration of 1,2-dichloroethane was reported as a range. EPA used a uniform distribution to model the 1,2-dichloroethane weight fraction within each product type. On each iteration of the simulation, the model executes each product's weight fraction distribution and the product frequency distribution. The model then reads the product selected from the product frequency distribution and selects the weight fraction that was generated from the corresponding product's weight fraction distribution. Table_Apx E-4 provides a summary of the reported 1,2-dichloroethane content reported in the safety data sheets and the fractional probability of each product type.

Table_Apx E-4. Summary of 1,2-Dichloroethane-Based Solvent Formulations

Source	1,2-Dichloroethane Weight Percent	Fractional Probability
(Pharmco Products, 2013 6286319)	90–100	0.50
(Occidental Chemical Corp, 2015)	99–100	0.50
	Total	**1.00**

E.2.2.8 Volume of Degreaser Used per Brake Job

CARB (2000) assumed that brake jobs require 14.4 oz of aerosol product. EPA did not identify other information to estimate the volume of aerosol product per job; therefore, EPA used a constant volume of 14.4 oz per brake job based on CARB (2000).

E.2.2.9 Number of Applications per Brake Job

Workers typically apply the brake cleaner before, during, and after brake disassembly. Workers may also apply the brake cleaner after brake reassembly as a final cleaning process (CARB, 2000). Therefore, EPA assumed a worker applies a brake cleaner three or four times per wheel. Because a brake job can be performed on either one axle or two axles (CARB, 2000), EPA assumed a brake job may involve either two or four wheels. Therefore, the number of brake cleaner (aerosol degreaser) applications per brake job can range from 6 (3 applications/brake × 2 brakes) to 16 (4 applications/brake × 4 brakes). EPA assumed a constant number of applications per brake job based on the midpoint of this range of 11 applications per brake job.

E.2.2.10 Amount of 1,2-Dichloroethane Used per Application

EPA calculated the amount of 1,2-dichloroethane used per application using Equation_Apx E-28. The calculated mass of 1,2-dichloroethane used per application ranges from 3.7 to 29.7 grams.

Equation_Apx E-28.

$$Amt = \frac{W_d \times wtfrac \times 28.3495 \frac{g}{oz}}{N_A}$$

Where:

Amt	=	Amount of 1,2-dichloroethane used per application (g/application)
W_d	=	Weight of degreaser used per brake job (oz/job)
$Wtfrac$	=	Weight fraction of 1,2-dichloroethane in aerosol degreaser (unitless)
N_A	=	Number of degreaser applications per brake job (applications/job)

This value was used as the daily amount released to the atmosphere.

E.2.2.11 Operating Hours per Week

CARB (2000) collected weekly operating hour data for 54 automotive maintenance and repair facilities. The surveyed facilities included service stations (fuel retail stations), general automotive shops, car dealerships, brake repair shops, and vehicle fleet maintenance facilities. The weekly operating hours of the surveyed facilities ranged from 40 to 122.5 hr/week. EPA fit a lognormal distribution to the surveyed weekly operating hour data. The resulting lognormal distribution has a mean of 16.943 and standard deviation of 13.813, which set the shape of the lognormal distribution. EPA shifted the distribution to the right such that its minimum value is 40 hr/week and set a truncation of 122.5 hr/week (the truncation is set as 82.5 hr/week relative to the left shift of 40 hr/week).

E.2.2.12 Number of Brake Jobs per Work Shift

CARB (2000) visited 137 automotive maintenance and repair shops and collected data on the number of brake jobs performed annually at each facility. CARB calculated an average of 936 brake jobs performed per facility per year. EPA calculated the number of brake jobs per work shift using the average number of jobs per site per year, the operating hours per week (varies according to lognormal distribution, see Section E.2.2.11 for discussion), and assuming 52 weeks of operation per year and 8 hours per work shift using Equation_Apx E-29 and rounding to the nearest integer. The calculated number of brake jobs per work shift ranges from one to four.

Equation_Apx E-29.

$$N_J = \frac{936 \frac{jobs}{site\text{-}year} \times 8 \frac{hours}{shift}}{52 \frac{weeks}{yr} \times OHpW}$$

Where:

N_J	=	Number of brake jobs per work shift (jobs/site-shift)
$OHpW$	=	Operating hours per week (hr/week).

E.2.2.13 Sensitivity of Model Parameters

The far-field volume, AER, and near-field indoor air speed exhibit inverse relationships with the calculated NF and FF 8-hour TWA concentrations, with concentrations increasing exponentially at progressively lower V_{FF} and AER values. EPA used triangular distributions for the far-field volume and AER, and a lognormal distribution for the near-field indoor air speed, as discussed in Sections E.2.2.1, E.2.2.2, and E.2.2.3 respectively. Generally, the AER value has a greater impact on exposure concentration than the far-field volume and indoor air speed.

Near-field volume also exhibits an inverse relationship with near-field (worker) exposure concentrations. However, this parameter was fixed as a single value within the model framework, based on the available data. Similarly to far-field volume, AER and near-field indoor air speed, smaller near-field volume values would result in calculated exposure concentrations increasing exponentially, while larger values would result in relatively small reductions in near-field exposure concentrations. Far-field exposure concentrations are largely unaffected.

The amount of 1,2-dichloroethane, which is based on the 1,2-dichloroethane weight fraction and the amount of degreaser used, has a linear relationship with both the NF and FF 8-hour TWA concentrations.

The amount of degreaser used was fixed, based on the available data, while the 1,2-dichloroethane weight fractions were varied based on a distribution as discussed in Section E.2.2.7.

Appendix F CONSIDERATION OF ENGINEERING CONTROLS AND PERSONAL PROTECTIVE EQUIPMENT

OSHA and NIOSH recommend employers utilize the hierarchy of controls to address hazardous exposures in the workplace. The hierarchy of controls strategy outlines, in descending order of priority, the use of elimination, substitution, engineering controls, administrative controls, and lastly PPE. The hierarchy of controls prioritizes the most effective measures first that is to eliminate or substitute the harmful chemical (*e.g.*, use a different process, substitute with a less hazardous material), thereby preventing or reducing exposure potential. Following elimination and substitution, the hierarchy recommends engineering controls to isolate employees from the hazard (*e.g.*, source enclosure, local exhaust ventilation systems), followed by administrative controls (*e.g.*, do not open machine doors when running), or changes in work practices (*e.g.*, maintenance plan to check equipment to ensure no leaks) to reduce exposure potential. Administrative controls are policies and procedures instituted and overseen by the employer to limit worker exposures. Under CFR 1910.1000, OSHA requires the use of engineering or administrative controls to bring exposures to the levels permitted under the air contaminants standard. The respirators do not replace engineering controls and they are implemented in addition to feasible engineering controls (29 CFR 1910.134(a)(1)). The PPE (*e.g.*, respirators, gloves) could be used as the last means of control when the other control measures cannot reduce workplace exposure to an acceptable level.

The remainder of this section discusses respiratory protection and glove protection, including protection factors for various respirators and dermal protection strategies. EPA's estimates of occupational exposure presented in this document do not assume the use of engineering controls or PPE; however, the effect of respiratory and dermal protection factors on the Agency's occupational exposure estimates can be explored in the "Risk Reduction" tab of the *Draft Risk Calculator for 1,2-Dichloroethane* (U.S. EPA, 2025j).

F.1 Respiratory Protection

OSHA's Respiratory Protection Standard (29 CFR 1910.134) requires employers in certain industries to address workplace hazards by implementing engineering control measures and, if these are not feasible, provide respirators that are applicable and suitable for the purpose intended. Engineering and administrative controls must be implemented whenever employees are exposed above the PEL. If engineering and administrative controls do not reduce exposures to below the PEL, respirators must be worn. Respirator selection provisions are provided in CFR 1910.134(d) and require that appropriate respirators are selected based on the respiratory hazard(s) to which the worker will be exposed and workplace and user factors that affect respirator performance and reliability. Assigned protection factors (APFs) are provided in Table 1 under CFR 1910.134(d)(3)(i)(A) (see below in Table_Apx F-1 and refer to the level of respiratory protection that a respirator or class of respirators could provide to employees when the employer implements a continuing, effective respiratory protection program. Implementation of a full respiratory protection program requires employers to provide training, appropriate selection, fit testing, cleaning, and change-out schedules in order to have confidence in the efficacy of the respiratory protection.

If respirators are necessary in atmospheres that are not immediately dangerous to life or health, workers must use NIOSH-certified air-purifying respirators or NIOSH-approved supplied-air respirators with the appropriate APF. Respirators that meet these criteria may include air-purifying respirators with organic vapor cartridges. Respirators must meet or exceed the required level of protection listed in Table_Apx F-1. Based on the APF, inhalation exposures may be reduced by a factor of 5 to 10,000 if respirators are properly worn and fitted.

For atmospheres that are immediately dangerous to life and health, workers must use a full facepiece pressure demand self-contained breathing apparatus (SCBA) certified by NIOSH for a minimum service life of 30 minutes or a combination full facepiece pressure demand supplied-air respirator (SAR) with auxiliary self-contained air supply. Respirators that are provided only for escape from an atmosphere that is immediately dangerous to life and health must be NIOSH-certified for escape from the atmosphere in which they will be used.

Table_Apx F-1. Assigned Protection Factors for Respirators in OSHA Standard 29 CFR 1910.134

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/ Hood	Loose-fitting Facepiece
1. Air-Purifying Respirator	5	10	50		
2. Power Air-Purifying Respirator (PAPR)		50	1,000	25/1,000	25
3. Supplied-Air Respirator (SAR) or Airline Respirator					
• Demand mode		10	50		
• Continuous flow mode		50	1,000	25/1,000	25
• Pressure-demand or other positive-pressure mode		50	1,000		
4. Self-Contained Breathing Apparatus (SCBA)					
• Demand mode		10	50	50	
• Pressure-demand or other positive-pressure mode (*e.g.*, open/closed circuit)			10,000	10,000	
Source: 29 CFR 1910.134(d)(3)(i)(A)					

NIOSH and BLS conducted a voluntary survey of U.S. employers regarding the use of respiratory protective devices between August 2001 and January 2002. The survey was sent to a sample of 40,002 establishments designed to represent all private sector establishments. The survey had a 75.5 percent response rate (Niosh, 2003). A voluntary survey may not be representative of all private industry respirator use patterns as some establishments with low or no respirator use may choose to not respond to the survey. Therefore, results of the survey may potentially be biased towards higher respirator use.

NIOSH and BLS estimated about 619,400 establishments used respirators for voluntary or required purposes (including emergency and non-emergency uses). About 281,800 establishments (45%) were estimated to have had respirator use for required purposes in the 12 months prior to the survey. The 281,800 establishments estimated to have had respirator use for required purposes were estimated to be approximately 4.5 percent of all private industry establishments in the United States at the time (Niosh, 2003).

The survey found that the establishments that required respirator use had the following respirator program characteristics (Niosh, 2003):

- 59 percent provided training to workers on respirator use;
- 34 percent had a written respiratory protection program;
- 47 percent performed an assessment of the employees' medical fitness to wear respirators; and
- 24 percent included air sampling to determine respirator selection.

The survey report does not provide a result for respirator fit testing or identify if fit testing was included in one of the other program characteristics.

Of the establishments that had respirator use for a required purpose within the 12 months prior to the survey, NIOSH and BLS found (Niosh, 2003) the following:

- Non-powered air purifying respirators are most common, 94 percent overall and varying from 89 to 100 percent across industry sectors.
- Powered air-purifying respirators represent a minority of respirator use, 15 percent overall and varying from 7 to 22 percent across industry sectors.
- Supplied air respirators represent a minority of respirator use, 17 percent overall and varying from 4 to 37 percent across industry sectors.

Of the establishments that used non-powered air-purifying respirators for a required purpose within the 12 months prior to the survey, NIOSH and BLS found (Niosh, 2003) the following:

- A high majority use dust masks, 76 percent overall and varying from 56 to 88 percent across industry sectors.
- A varying fraction use half-mask respirators, 52 percent overall and varying from 26 to 66 percent across industry sectors.
- A varying fraction use full-facepiece respirators, 23 percent overall and varying from 4 to 33 percent across industry sectors.

Table_Apx F-2 summarizes the number and percent of all private industry establishments and employees that used respirators for a required purpose within the 12 months prior to the survey and includes a breakdown by industry sector (Niosh, 2003).

Table_Apx F-2. Number and Percent of Establishments and Employees Using Respirators Within 12 Months Prior to Survey

Industry	Establishments		Employees	
	Number	Percent of All Establishments	Number	Percent of All Employees
Total Private Industry	281,776	4.5	3,303,414	3.1
Agriculture, Forestry, and Fishing	13,186	9.4	101,778	5.8
Mining	3,493	11.7	53,984	9.9
Construction	64,172	9.6	590,987	8.9
Manufacturing	48,556	12.8	882,475	4.8
Transportation and Public Utilities	10,351	3.7	189,867	2.8
Wholesale Trade	31,238	5.2	182,922	2.6
Retail Trade	16,948	1.3	118,200	0.5
Finance, Insurance, and Real Estate	4,202	0.7	22,911	0.3
Services	89,629	4.0	1,160,289	3.2

F.2 Glove Protection

OSHA’s hand protection standard (29 CFR 1910.138) requires employers select and require employees to use appropriate hand protection when expected to be exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes. Dermal protection selection provisions are provided in CFR 1910.138(b) and require that appropriate hand protection is selected based on the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards to which employees will be exposed.

Unlike respiratory protection, OSHA standards do not provide protection factors (PFs) associated with various hand protection PPE, such as gloves, and data about the frequency of effective glove use—that is, the proper use of effective gloves—is very limited in industrial settings. Initial literature review suggests that there is unlikely to be sufficient data to justify a specific probability distribution for effective glove use for a chemical or industry. Instead, the impact of effective glove use is explored by considering different percentages of effectiveness.

Gloves only offer barrier protection until the chemical breaks through the glove material. Using a conceptual model, Cherrie (Cherrie et al., 2004) proposed a glove workplace protection factor – the ratio of estimated uptake through the hands without gloves to the estimated uptake though the hands while wearing gloves: this protection factor is driven by flux and thus varies with time. The ECETOC TRA Model represents the protection factor of gloves as a fixed, assigned protection factor equal to 5, 10, or 20 (Marquart et al., 2017) where, similar to the APF for respiratory protection, the inverse of the protection factor is the fraction of the chemical that penetrates the glove. It should be noted that the described PFs are not based on experimental values or field investigations of PPE effectiveness, but rather professional judgements used in the development of the ECETOC TRA Model. EPA did not identify reasonably available information on PPE usage to corroborate the PFs used in this model.

As indicated in Table_Apx F-3, use of protection factors above 1 is recommended only for glove materials that have been tested for permeation against the 1,2-dichloroethane-containing liquids associated with the condition of use. EPA has not found information that would indicate specific activity training (*e.g.*, procedure for glove removal and disposal) for tasks where dermal exposure can be expected to occur in a majority of sites in industrial only OESs, so the PF of 20 would usually not be expected to be achieved.

Table_Apx F-3. Glove Protection Factors for Different Dermal Protection Strategies from ECETOC TRA v3

Dermal Protection Characteristics	Affected User Group	Indicated Efficiency (%)	Protection Factor, PF
a. Any glove / gauntlet without permeation data and without employee training	Both industrial and professional users	0	1
b. Gloves with available permeation data indicating that the material of construction offers good protection for the substance		80	5
c. Chemically resistant gloves (*i.e.*, as b. above) with "basic" employee training		90	10
d. Chemically resistant gloves in combination with specific activity training (*e.g.*, procedure for glove removal and disposal) for tasks where dermal exposure can be expected to occur	Industrial users only	95	20