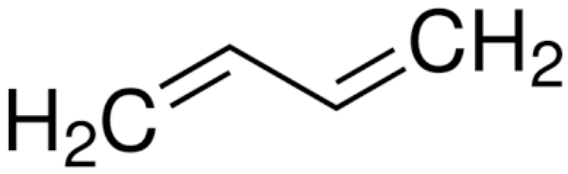
United States
Environmental Protection Agency

November 2024
Office of Chemical Safety and
Pollution Prevention

Draft Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene

Technical Support Document for the Draft Risk Evaluation

CASRN: 106-99-0



November 2024

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

LIST OF APPENDIX FIGURES

ABBREVIATIONS AND ACRONYMS

AC	Acute concentrations
ACC	American Chemistry Council
ADC	Average daily concentrations
$ADC_{intermediate}$	Intermediate average daily concentrations
BLS	Bureau of Labor Statistics
CAA	Clean Air Act
CAP	Criteria Air Pollutant
CDC	Centers for Disease Control and Prevention
CDR	Chemical Data Reporting
CEHD	OSHA Chemical Exposure Health Database
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COU	Condition of use
DMR	Discharge Monitoring Report
DOD	U.S. Department of Defense
DOT	Department of Transportation
EIS	Emissions Inventory System
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
ESD	Emission Scenario Document
FR	Federal Register
GS	Generic scenario
HAP	Hazardous air pollutant
IISRP	International Institute of Synthetic Rubber Producers
LADC	Lifetime average daily concentrations
LOD	Limit of detection
LPG	Liquified petroleum gas
NAAQS	National Ambient Air Quality Standard
NAICS	North American Industry Classification System (codes)
NCR	National Response Center
NEI	National Emissions Inventory

NESHAP	National Emission Standard for Hazardous Air Pollutants
NIOSH	National Institution for Occupational Safety and Health
OCSPP	Office of Chemical Safety and Pollution Prevention
OEL	Occupational exposure limits
OES	Occupational exposure scenario
ONU	Occupational non-user
OPPT	Office of Pollution Prevention and Toxics
OSHA	Occupational Safety and Health Administration
PBZ	Personal breathing zone
PEL	Permissible Exposure Limits
POTW	Publicly owned treatment works
PPE	Personal protective equipment
PV	Production volume
SDS	Safety data sheet
SIC	Standard Industrial Classification (codes)
SLT	State, local, and tribal
SPIN	Substances in Preparations in Nordic Countries
SOC	Standard Occupational Classification (codes)
SUSB	U.S. Census' Statistics of US Businesses
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TWA	Time-weighted average
WWT	Wastewater treatment

ACKNOWLEDGEMENTS

The Assessment Team gratefully acknowledges the participation, review, and input from U.S. Environmental Protection Agency (EPA or the Agency) Office of Pollution Prevention and Toxics (OPPT) and Office of Chemical Safety and Pollution Prevention (OCSPP) senior managers and science advisors. The Agency is also grateful for assistance from the following EPA contractors for the preparation of this draft technical support document: ERG (Contract No. 68HERD20A0002). Special acknowledgement is given for the contributions of technical experts through the ERG contract.

Docket

Supporting information can be found in the public docket, Docket ID: EPA-HQ-OPPT-2024-0425.

Disclaimer

Reference herein to any specific commercial products, process or service by trade name, trademark, manufacturer, or otherwise does not constitute or imply its endorsement, recommendation, or favoring by the United States Government.

Authors: Michael Stracka and Catherine Taylor

Contributors: Sheila Healy, Whitney Hollinshead and Joseph Rappold.

Technical Support: Mark Gibson, Hillary Hollinger, Grace Kaupas, and Kelley Stanfield.

This draft technical support document (TSD) was reviewed and cleared for release by OPPT and OCSPP leadership.

SUMMARY

Environmental Release and Occupational Exposure: Key Points

EPA considered all reasonably available information identified by the Agency through its systematic review process under the Toxic Substances Control Act (TSCA) (U.S. EPA, 2024k) to characterize environmental releases of and occupational exposure to 1,3-butadiene, a colorless gas. The following points summarize the environmental release and occupational exposure from 1,3-butadiene:

- 1,3-Butadiene has a total production volume (PV) in the United States between 1 and 5 billion pounds (lb) from the 2020 Chemical Data Reporting (CDR) reporting period (U.S. EPA, 2020b).
- 1,3-Butadiene is primarily used as a monomer in the production of a wide range of polymers and copolymers. It is also used as an intermediate in the production of several chemicals.
- EPA evaluated environmental releases and occupational exposures for each occupational exposure scenario. OESs were developed based on a set of occupational activities and conditions such that similar occupational exposures to and environmental releases are expected from the use(s) covered under each OES. The Agency provided environmental release and occupational exposure results for each OES, which are expected to be representative of the population of 1,3-butadiene workers and sites for the given OES in the United States.
- EPA used release data from the databases Toxics Release Inventory (TRI) and the National Emissions Inventory (NEI) to assess releases to air, land, and water for a majority of 1,3-butadiene uses. One exception was the release from the use of adhesives and sealants, for which modeling approaches were used.
- A majority of releases of 1,3-butadiene were to air, with land and water releases occuring at far fewer sites.
- The OESs with the highest expected releases were manufacturing, plastic and rubber compounding, and application of adhesives and sealants.
- Uncertainty was introduced to the 1,3-butadiene release assessment due to both the lack of facility PV data and the use of generic models when site-specific data was not available.
- EPA used inhalation monitoring data to evaluate acute, intermediate, and chronic exposures to workers and occupational non-users (ONUs) for each OES. Where no monitoring data existed relevant to certain OESs, analogous monitoring data were used.
- Inhalation exposures to 1,3-butadiene from most industrial and commercial OESs are expected to be rather low, with the exception of repackaging.
- Uncertainty was introduced to the exposure assessment due to lack of directly applicable monitoring data for certain OESs, thus leading to the use of analogous monitoring data, and in site-specific differences in use practices and engineering controls for 1,3-butadiene.

This technical document supports the *Draft Risk Evaluation for 1,3-Butadiene* (also called the "1,3-butadiene draft risk evaluation" or "draft risk evaluation") {U.S. EPA, 2024, 11363699}. 1,3-Butadiene is a TRI-reportable substance effective January 1, 1987 (40 CFR 372.65), is included on EPA's initial list of hazardous air pollutants (HAPs) under the Clean Air Act (CAA) and is a hazardous substance under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This

draft assessment describes the use of reasonably available information to estimate environmental releases of 1,3-butadiene and evaluate occupational exposure to workers and ONUs. The latter are those who may work in the vicinity of chemical-related activities but do not handle the chemicals themselves, such as managers or inspectors. See the draft risk evaluation {U.S. EPA, 2024, 11363699}for a complete list of all the technical support documents (TSDs) for the 1,3-butadiene draft risk evaluation.

Focus of the Module on Environmental Release and Occupational Exposure Assessment

During scoping, EPA considered all known TSCA uses for 1,3-butadiene. 1,3-Butadiene is a colorless gas with a total production volume (PV) in the United States between 1 and 5 billion pounds from the 2020 CDR reporting period (U.S. EPA, 2020b). It is primarily used as a monomer in the production of a wide range of polymers and copolymers, but is also used as an intermediate in the production of several chemicals. The American Chemistry Council (ACC) reported in 2018 that roughly 63 to 69 percent of 1,3-butadiene PV goes toward the production of polymers and copolymers such as polybutadiene and styrene-butadiene rubber, while 26 to 32 percent goes toward the production of adiponitrile, chloroprene, and other intermediate chemicals. The remainder of the PV for 1,3-butadiene may go to either of these uses or support other uses such as use as a laboratory chemical (EPA-HQ-OPPT-2018-0451-0021).

Exposures to workers, consumers, the general population, and ecological species may occur from industrial, commercial, and consumer uses of 1,3-butadiene and 1,3-butadiene-containing articles, as well as from releases to air, water, or land. Workers and ONUs may be exposed to 1,3-butadiene during conditions of use (COUs), such as chemical manufacturing, processing as a reactant, and plastics and rubber compounding. Exposure to the general population and ecological species may occur from industrial and commercial releases related to the manufacture, import, processing, distribution, and use of 1,3-butadiene. This draft TSD provides the details of the assessment of the environmental releases and occupational exposures from each TSCA COU of 1,3-butadiene, and does not include releases resulting from consumer uses.

Approach for Assessing Environmental Releases and Occupational Exposures

EPA evaluated environmental releases of 1,3-butadiene to air, water, and land from the conditions of use assessed in this risk evaluation. EPA used release data from the TRI and NEI databases to assess releases for a majority of COUs. One exception was the release from the use of adhesives and sealants, for which modeling approaches were used.

EPA evaluated acute, intermediate, and chronic exposures to workers and ONU associated with 1,3-butadiene COUs, including Agency use of inhalation monitoring data from public comments and literature sources. Where no 1,3-butadiene monitoring data existed relevant to certain COUs, EPA used monitoring data from analogous uses.

Results for Environmental Releases and Occupational Exposures

EPA evaluated environmental releases and occupational exposures for individual OESs. Each OES is developed based on a set of occupational activities and conditions such that similar occupational exposures and environmental releases are expected from the use(s) covered under the OES. For each OES, EPA provided environmental release and occupational exposure results, which are expected to be representative of the population of workers and sites for the given OES in the United States.

EPA evaluated environmental releases of 1,3-butadiene to air, water, and/or land for each OES assessed in the draft risk evaluation. A majority of releases of 1,3-butadiene were to air, with land and water releases occuring at far fewer sites. The OESs with the highest expected releases were manufacturing, plastic and rubber compounding, and application of adhesives and sealants.

EPA also evaluated inhalation exposures to worker populations, including ONU, for each OES. The occupational exposure assessment has shown that inhalation exposures to 1,3-butadiene from most industrial and commercial COUs are expected to be , with the exception of the COU for repackaging. Because repackaging work activities would be mostly related to connecting and disconnecting lines to ship and transport liquified butadiene, monitoring data show that it is possible for such operations to lead to higher levels of inhalation exposure. Detailed exposure results for each OES and exposure route can be found in Section 3.

Uncertainties

Uncertainties exist with the monitoring and modeling approaches used to assess 1,3-butadiene environmental releases and occupational exposures. For example, the lack of 1,3-butadiene facility PV data and use of throughput estimates based on CDR reporting thresholds may not be representative of the actual PV of 1,3-butadiene used in the United States. There were also cases where EPA used generic models and default input parameter values when site-specific data was not available, or analogous monitoring data when directly applicable data was not available. In addition, site-specific differences in use practices and engineering controls exist, but are largely unknown, which represents another source of variability that EPA could not quantify in the assessment.

Environmental and Exposure Pathways Considered

EPA used environmental releases to air, water, and land to estimate exposures to the general population and ecological species for 1,3-butadiene COUs. The environmental release estimates developed by the Agency are used to estimate the presence of 1,3-butadiene in the environment and biota and evaluate the environmental hazards. The release estimates were used to model exposure to the general population and ecological species where environmental monitoring data were not available.

EPA assessed risks for acute, intermediate, and chronic exposure scenarios in workers (those directly handling 1,3-butadiene) and ONUs for 1,3-butadiene COUs. The Agency assumed that workers and ONUs would be individuals of both sexes (age 16+ years, including pregnant workers) based upon occupational work permits—although exposures to younger workers in occupational settings cannot be ruled out. An objective of the monitored inhalation data was to provide separate exposure level estimates for workers and ONUs.

1 INTRODUCTION

1.1 Overview

This document provides details on the environmental release and occupational exposure assessment and supports the draft risk evaluation for 1,3-butadiene under the Frank R. Lautenberg Chemical Safety for the 21st Century Act, which amended TSCA in 2016. TSCA section 6(b)(4) requires the United States Environmental Protection Agency (EPA or the Agency) to establish a risk evaluation process. In performing risk evaluations for existing chemicals, EPA is directed to "determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other non-risk factors, including an unreasonable risk to a potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator under the conditions of use." In December 2019, EPA published a list of 20 chemical substances designated high priority substances for risk evaluations (84 FR 71924, December 30, 2019), as required by TSCA section 6(b)(2)(B), which initiated the risk evaluation process for those chemical substances. 1,3-Butadiene is one of the chemicals designated as a high-priority substance for risk evaluation.

1,3-Butadiene is a colorless gas with a total PV in the United States between 1 and 5 billion lb from the 2020 CDR reporting period (U.S. EPA, 2020b). It is a TRI-reportable substance effective January 1, 1987 (40 CFR 372.65), is included on EPA's initial list of HAPs under the CAA, and it is a hazardous substance under CERCLA. 1,3-Butadiene is primarily used as a monomer in the production of a wide range of polymers and copolymers. It is also used as an intermediate in the production of several chemicals. It was reported by ACC in 2018 that roughly 63 to 69 percent of 1,3-butadiene PV goes toward the production of polymers and copolymers such as polybutadiene and styrene-butadiene rubber, while roughly 26 to 32 percent goes toward the production of intermediate chemicals such as adiponitrile and chloroprene. The remainder of the PV may go to either of these uses or other uses such as use as a laboratory chemical (EPA-HQ-OPPT-2018-0451-0021).

The life cycle diagram is a graphical representation of the various life stages of the industrial, commercial, and consumer use categories included within the scope of this risk evaluation, *Final Scope of the Risk Evaluation for 1,3-Butadiene; CASRN 106-99-0* (also called the "final scope for 1,3-butadiene") (U.S. EPA, 2020c). The information in the life cycle diagram is grouped according to CDR processing codes and use categories (including functional use codes for industrial uses and product categories for industrial, commercial, and consumer uses). 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. EPA collects CDR data approximately every 4 years with the latest collections occurring in 2020. This document contains additional descriptions (*e.g.*, process descriptions, worker activities, process flow diagrams) for each manufacturing, processing, use, and disposal category.

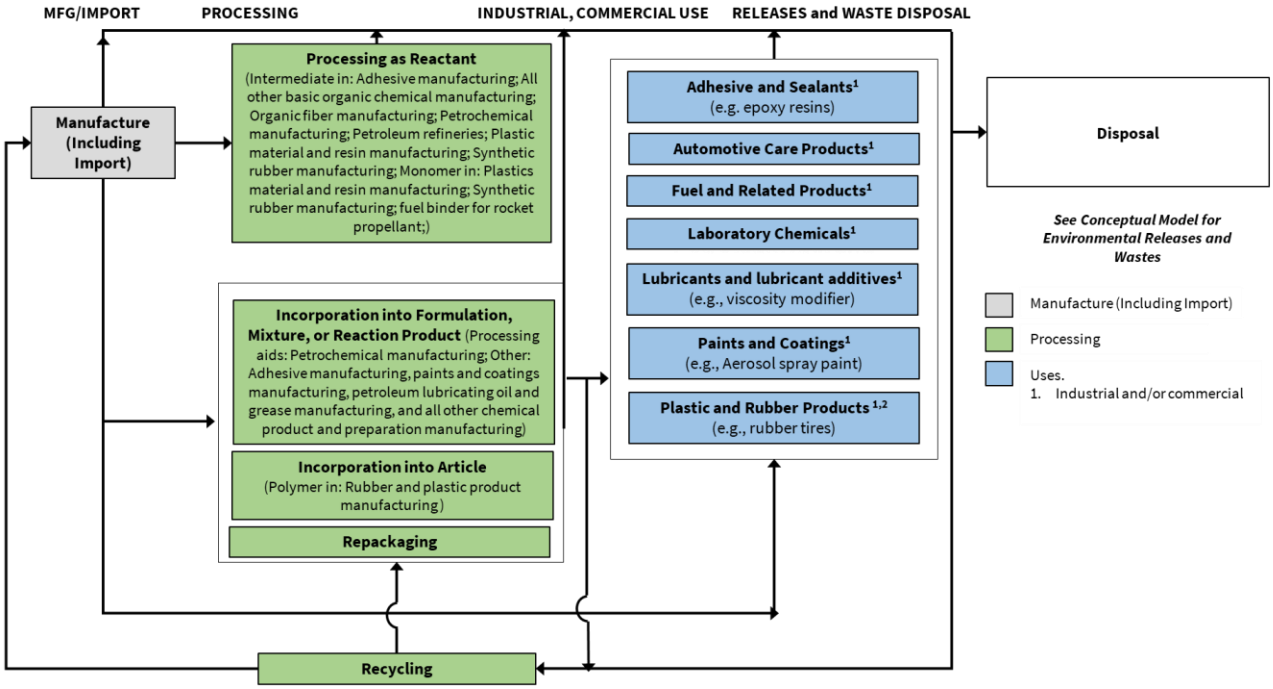


Figure 1-1. 1,3-Butadiene Life Cycle Diagram

This draft assessment addresses environmental releases of 1,3-butadiene in industrial and commercial settings. Releases of 1,3-butadiene 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 but can be found in the other TSDs that support the draft risk evaluation of 1,3-butadiene. This document also addresses occupational exposure that may occur in these industrial and commercial settings. The risks associated with these exposures are calculated in the *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2024i), which is discussed in the *Draft Risk Evaluation for 1,3-Butadiene* (U.S. EPA, 2024j). In the sections that follow, the scope, methods used, and the results of this 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 *Draft Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure for 1,3-Butadiene* (U.S. EPA, 2024e) and EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021a) respectively.

1.2 Scope of the Risk Evaluation

The TSCA risk evaluation of 1,3-butadiene comprises several human health, environmental, fate, and exposure assessment modules, and a risk evaluation document. A diagram showing the relationships between assessments is provided in Figure 1-2. This environmental release and occupational exposure assessment is one of five technical support documents that are outlined in green.

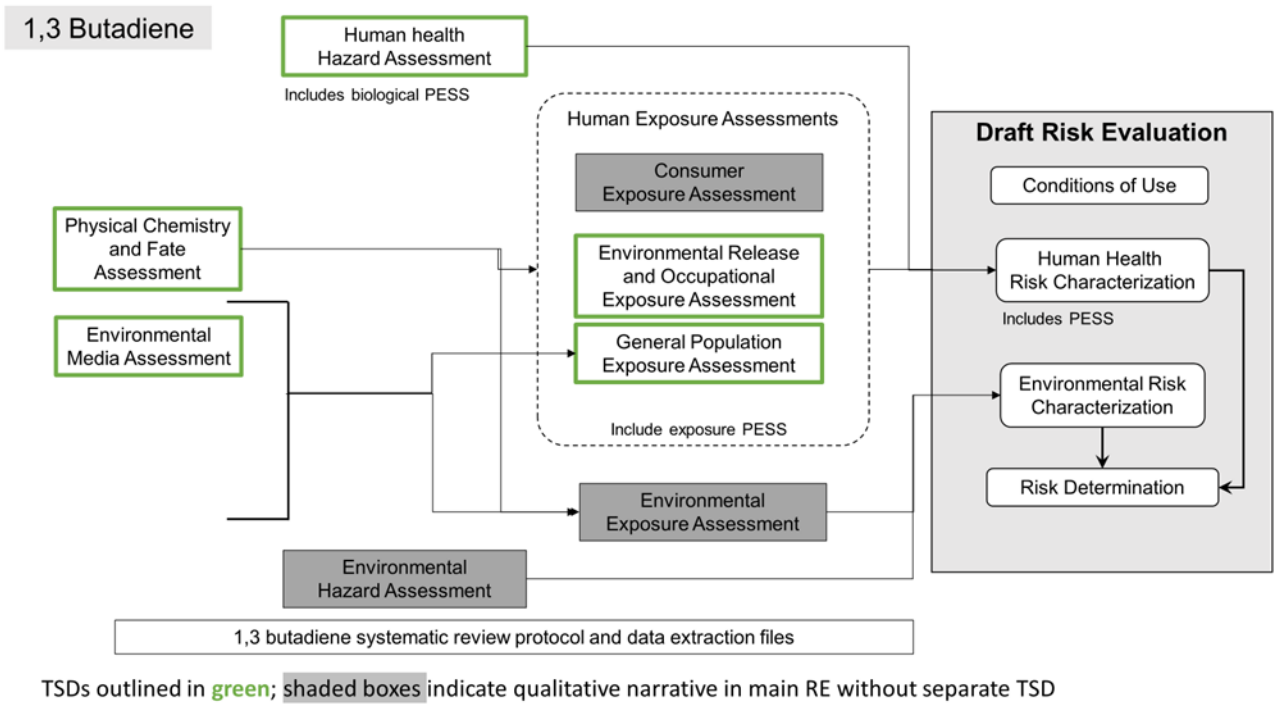


Figure 1-2. Risk Assessment Document Map Summary

EPA assessed environmental releases and occupational exposures for COUs as described in Table 2-1 of the *Draft Risk Evaluation for 1,3-Butadiene* (U.S. EPA, 2024j). These COUs are also listed 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 1,3-Butadiene; CASRN 106-99-0* (U.S. EPA, 2020c), though the COUs presented may change between the scope document and the risk evaluation itself as the assessment is conducted and more information about the chemical is gathered. Each COU has a unique combination of Lifestyle Stage, Category, and Subcategory that describes the chemical's use. As shown in Table 1-1, EPA has identified 28 COUs for 1,3-butadiene.

Each COU for 1,3-butadiene was assigned an OES that characterizes its release and exposure potential. Though named for their utility when assessing occupational exposure, these scenarios are also used when assessing environmental releases from industrial and commercial facilities. OES is a term that is intended to describe the grouping or segmenting of COUs for assessment of releases and exposures. For example, 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, environmental releases and occupational exposure results are provided and are expected to be representative of the population of workers and sites involved for the given OES in the United States. Figure 1-3 depicts the ways that COUs may be mapped to OESs.

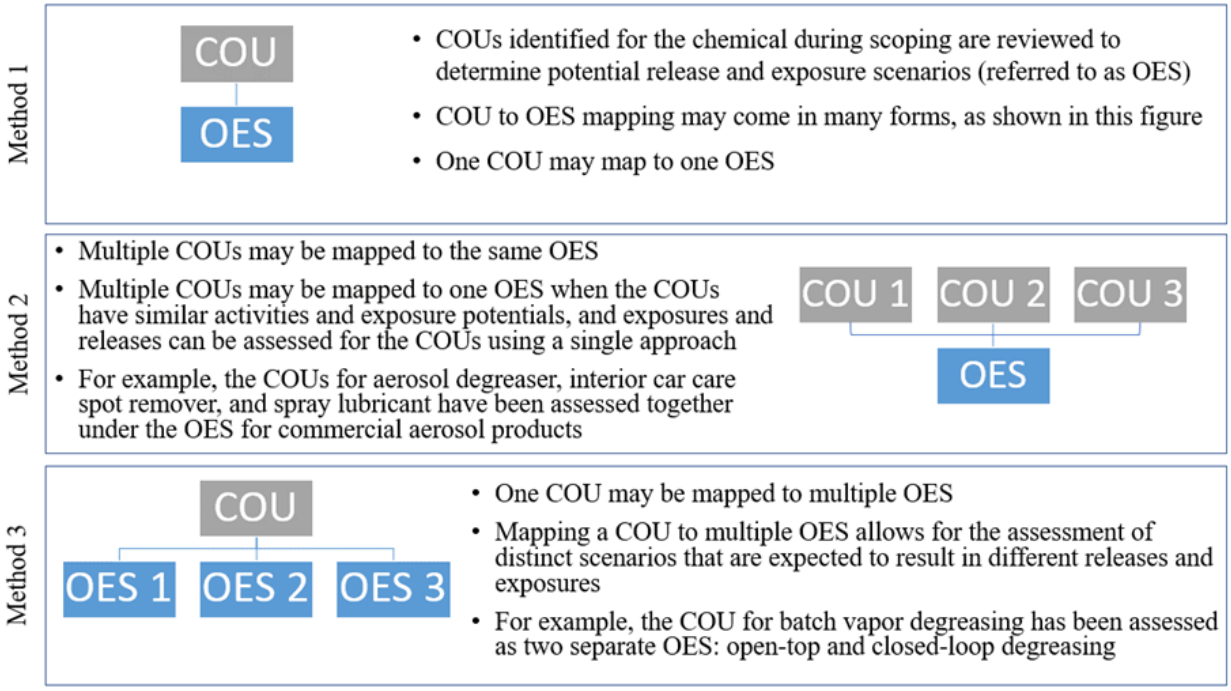


Figure 1-3. Conditions of Use to Occupational Exposure Mapping

Table 1-1 shows mapping between the COUs of use in Table 2-1 of the draft risk evaluation (U.S. EPA, 2024j) to the OESs assessed in this report. For 1,3-butadiene, EPA mapped OESs to COUs based on data and information gathered during systematic review, industry outreach, and public comments. Several of the condition of use 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, "importing" and "intermediate in: wholesale and retail trade" were both assessed under the "repackaging" OES. This grouping minimized repetitive assessments. In one case, the condition of use subcategory was further delineated into multiple OESs based on expected differences in process equipment and associated releases or exposure potentials between facilities. This case was "disposal," which was delineated into "waste handling, treatment, and disposal" and "recycling." A total of 15 unique OESs were identified. Table 1-1 lists each COU (defined by its unique combination of a life cycle stage, category, and subcategory) and its corresponding OES.

705 **Table 1-1. Crosswalk of Conditions of Use to Occupational Exposure Scenarios Assessed**

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario
Manufacture	Domestic manufacturing	Domestic manufacturing	Domestic manufacturing
	Importing	Importing	Repackaging
Processing	Processing as a reactant	Intermediate in: Adhesive manufacturing; All other basic organic chemical manufacturing; Fuel binder for solid rocket fuels; Organic fiber manufacturing; Petrochemical manufacturing; Petroleum refineries; Plastic material and resin manufacturing; Propellant manufacturing; Synthetic rubber manufacturing; Paint and coating manufacturing; Wholesale and retail trade	Processing as a reactant
		Monomer used in polymerization process in: Synthetic Rubber Manufacturing; Plastic material and resin manufacturing	Plastics and rubber compounding
	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: Petrochemical manufacturing; Monomers used in: Plastic product manufacturing; Synthetic rubber manufacturing	Processing – incorporation into formulation, mixture, or reaction product
		Other: Adhesive manufacturing, paint and coating manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	Processing – incorporation into formulation, mixture, or reaction product
	Processing – incorporation into article	Other: Polymer in: Rubber and plastic product manufacturing	Plastics and rubber converting
	Repackaging	Intermediate in: Wholesale and retail trade; Monomer in: Synthetic Rubber Manufacturing	Repackaging
	Recycling	Recycling	Processing as a Reactant
			Use of plastics and rubber products[e]
Distribution in Commerce	Distribution in commerce	Distribution in commerce (*e.g.*, Sold to a trader; Sold to re-sellers for petroleum fuel and petrochemical industry in: Petrochemical manufacturing)	Distribution in commerce[d]
Industrial Use	Adhesives and sealants	Adhesives and sealants, including epoxy resins	Application of adhesives and sealants

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario
Commercial Use	Fuels and related products	Fuels and related products	Fuels and related products
	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Use of plastics and rubber products[e]
	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	
	Synthetic Rubber	Synthetic Rubber (*e.g.*, rubber tires)	
	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	
	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	
	Automotive care products	Automotive care products	Use of plastics and rubber products[e]
	Other use	Laboratory chemicals	Use of laboratory chemicals
	Lubricants and lubricant additives	Lubricant additives, including viscosity modifier	Use of lubricants and greases[e]
	Paints and coatings	Paints and coatings, including aerosol spray paint	Application of paints and coatings

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario
	Adhesives and sealants	Adhesives and sealants, including epoxy resins	Application of adhesives and sealants
Consumer Use	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard)	N/A[f]
	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)	
	Synthetic Rubber	Synthetic Rubber (*e.g.*, rubber tires)	
	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles	
	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)	
Disposal	Disposal	Disposal	Waste handling, treatment, and disposal
			Recycling

[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.

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario

- 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 conditions of use appear in the Life Cycle Diagram, reflect CDR codes, and broadly represent conditions of use of 1,3-butadiene in industrial and/or commercial settings.

[c] These subcategories reflect more specific conditions of use of 1,3-butadiene.

- "Incorporation into article – polymer in rubber product manufacturing," as reported to the 2016 CDR, is a condition of use that EPA considered as manufacturing of articles involving butadiene-derived polymers, including plastics such as acrylonitrile butadiene styrene made using polybutadiene rubber.
- "Monomer used in polymerization process," as reported to the 2016 CDR under commercial use, indicates processing of 1,3-butadiene for a polymerization reaction. This reported use was evaluated under processing as a reactant.

[d] 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 1,3-butadiene distribution.

[e] Though these uses were identified during scoping, upon further investigation EPA made the decision to not quantitatively assess these uses of 1,3-butadiene. For a description of the rationale for not performing a quantitative assessment, and details for each decision, see Section 3.14.

[f] Consumer uses are not assigned to OESs but are assessed elsewhere in the assessment.

After identifying those OESs that will be assessed, the next step was to describe the function of 1,3-butadiene within each OES (Table 1-2). This would be utilized in mapping release and exposure data to an OES as well as applying release modeling approaches. Table 1-2 below is a summary; for more information on each OES see the corresponding process description in Section 3.

Table 1-2. Description of the Function of 1,3-Butadiene for Each OES

OES	Role/Function of 1,3-Butadiene
Manufacturing	This OES captures the Domestic manufacture COU category. 1,3-Butadiene can be produced by three processes: steam cracking of paraffinic hydrocarbons (the ethylene coproduct process), catalytic dehydrogenation of n-butane and n-butene (the Houndry process), and oxidative dehydrogenation of n-butene (the Oxo-D or O-X-D process). The predominant method of the three processes is the steam cracking process, which accounts for greater than 91% of the world's butadiene supply.
Repackaging	This OES captures the Importing and Repackaging COU categories. Import and repackaging sites are expected to distribute 1,3-butadiene to various downstream uses. Liquefied butadiene is shipped by pipelines, ships, barges, rail tank cars, tank trucks and bulk liquid containers. A portion of the 1,3-butadiene manufactured is also expected to be repackaged into smaller containers for commercial laboratory use.
Processing as a reactant	This OES captures the Processing as an Intermediate COU subcategory and part of the Recycling COU category. Processing as a reactant or intermediate is the use of 1,3-butadiene as a

OES	Role/Function of 1,3-Butadiene
	feedstock in the production of another chemical via a chemical reaction in which 1,3-butadiene is consumed to form the product. 1,3-Butadiene is used in the production of intermediate chemicals which are then used to make nylon and neoprene rubber among other products. 1,3-butadiene is also processed as a reactant in propellant manufacturing by the US Department of Defense. Also included in this OES is when ethylene manufacturers have excess butadiene supply, they can recycle the butadiene as a feedstock to produce ethylene.
Processing – Incorporation into formulation, mixture, or reaction product	This OES captures the Processing –incorporation 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 single product or preparation. 1,3-Butadiene may be used during lubricant manufacturing as a viscosity improver, as well as in paints, coatings, and adhesive manufacturing as a binder.
Plastic and rubber compounding	This OES captures the Processing as a Monomer COU subcategory. 1,3-Butadiene is used as a monomer in polymerization processes, often to produce rubbers and plastics such as styrene-butadiene, polybutadiene, acrylonitrile-butadiene-styrene, and nitrile rubber. This is the most common use of 1,3-butadiene.
Plastics and rubber converting	This OES captures the Processing –incorporation into article COU category. After the compounding process that occurs during the plastic and rubber compounding OES briefly described above, compounded plastic and rubber resins are converted into solid articles.
Distribution in commerce	This OES captures the Distribution in Commerce COU category. 1,3-Butadiene is expected to be distributed in commerce for the purposes of each processing, industrial, and commercial use of 1,3-butadiene. EPA expects 1,3-butadiene to be transported from manufacturing sites to downstream processing and repackaging sites.
Use of laboratory chemicals	This OES captures the Laboratory chemicals COU subcategory. 1,3-butadiene uses as a laboratory chemical may include demonstration of Diels Alder reactions, synthesis of thermoplastic resins, and synthesis of disilylated dimers by reacting with chlorosilanes.
Application of paints and coatings	This OES captures the Paints and coatings COU category. 1,3-butadiene was identified as possibly being present in multiple paint and coating products, including aerosol propellants, architectural paints and coatings, latex paints, electro-dipping coatings, and automotive primers. The application procedure depends on the type of paint or coating formulation and the type of substrate, but may involve application via brush, spray, roll, dip, curtain, or syringe or bead.
Application of adhesives and	This OES captures the Industrial use of adhesives and sealants, as well as the

OES	Role/Function of 1,3-Butadiene
sealants	Commercial use of adhesives and sealants COU categories. 1,3-Butadiene was identified in multiple adhesive and sealant products, including aerosol propellants, epoxy resins (incorporated for their tensile and elastomeric properties), and adhesives for electrical and circuit boards. The application procedure depends on the type of adhesive or sealant formulation and the type of substrate but may involve application via brush, spray, roll, dip, curtain, or syringe or bead.
Fuels and related products	This OES captures the Fuels and related products COU category. 1,3-Butadiene may be used at industrial sites for fueling purposes. This use of 1,3-butadiene is addressed in the Recycling OES. EPA did not find evidence that 1,3-butadiene in its monomer form is used as an additive to fuel, however it was found that 1,3-butadiene is present in butane. This use is discussed, but no release or exposure estimates provided.
Recycling	This OES captures part of the Disposal COU category. There are multiple ways 1,3-butadiene can be recycled during its lifecycle. When finished 1,3-butadiene does not meet commercial specifications, it is often combined with crude streams for energy recovery. This is examined in this OES.
Waste handling, treatment, and disposal	This OES captures part of the Disposal COU category. Each of the OES may generate waste streams of 1,3-butadiene that are collected and transported to third-party sites for disposal or treatment, and these cases are assessed under this OES. Also handled under this OES are cases of 1,3-butadiene produced as a byproduct or impurity in an industrial setting and burned.
Use of plastics and rubber products	This OES captures the five plastic and rubber COU categories detailed in the Commercial use life cycle stage as well as the automative care products and part of the Recycling COU categories. 1,3-Butadiene may be present within rubber tires and articles produced with synthetic rubber. In addition, plastics containing 1,3-butadiene were identified in electronic appliances, furniture and furnishings, toys and recreational products, housewares, packaging, automotive parts, building materials, and 3D-printing filament. Plastic and rubber products may be recycled mechanically (injection molding, extrusion, rotational molding and compression molding) into newly shaped products. Tires may also be recycled into tire crumbs for use on synthetic turf fields. Most automotive applications of 1,3-butadiene pertain to tires, tire products, and coatings and thus falls under plastic and rubber products described above. It was determined that butadiene is present in rubber products at no greater

OES	Role/Function of 1,3-Butadiene
	amounts than 6.6 ppm, and after polymerization occurs it is nearly impossible to break the polymer chain back into individual units of 1,3-butadiene. No release or exposure numbers are provided for this OES.
Use of lubricants and greases	This OES captures the Lubricants and lubricant additive COU category. 1,3-Butadiene has been identified in automotive lubricants and aircraft lubricants. 1,3-Butadiene monomer is present at very low levels within the finished styrene-butadiene copolymer product. Further, due to lack of evidence otherwise, it was determined that 1,3-butadiene is not present within lubricants and greases for any purpose other than the amount that may be residual within the styrene-butadiene copolymer. No release or exposure numbers are provided for this OES.

EPA reviewed release data from TRI (data from 2016–2021) and the NEW (data from 2017 and 2020) to identify relevant releases of 1,3-butadiene to the environment. The Agency also reviewed the Discharge Monitoring Report (DMR, data from 2016–2021) but found no evidence of 1,3-butadiene release within the timeframes assessed. While these databases sufficiently informed industrial and processing COUs, the databases are limited in data on environmental releases for commercial COUs and when necessary, EPA used modeling to estimate releases to the environment. These databases may not identify all 1,3-butadiene releases as some facilities may not be required to report.

EPA's assessment of releases includes quantifying annual and daily releases of 1,3-butadiene to air, water, and land. Releases to air include both fugitive and stack air emissions and emissions resulting from on-site waste treatment equipment, such as incinerators. For purposes of this report, releases to water include both direct discharges from industrial facilities to surface water and indirect discharges to publicly owned treatment works (POTW) or non-POTW wastewater treatment (WWT). Releases to land include any disposal of liquid or solids wastes containing 1,3-butadiene into landfills, land treatment, surface impoundments, or other land applications.

1,3-Butadiene is also generated as a byproduct from the incomplete combustion of fuel. EPA did not assess environmental releases or occupational exposures resulting from 1,3-butadiene formed as a byproduct (*e.g.,* exhaust emissions). EPA believes it is more appropriate to evaluate the potential risks arising from the byproduct within the scope of the risk evaluation for fuel from which the 1,3-butadiene is produced, rather than the 1,3-butadiene risk evaluation.

The purpose of this draft assessment is to quantify releases (along with occupational exposure, discussed below); therefore, downstream environmental fate and transport factors used to estimate exposures to the general population and ecological species are not discussed. Environmental fate and transport of 1,3-butadiene is discussed in the *Draft Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2024h). The details on how these factors were considered when determining risk are described in the *Draft Risk Evaluation for 1,3-Butadiene* (U.S. EPA, 2024j).

EPA's assessment of occupational exposures includes quantifying inhalation exposures to 1,3-butadiene. The Agency categorizes occupational exposures into two groups: exposures to workers and exposures to ONUs. Generally, EPA distinguishes workers as directly handling 1,3-butadiene as part of their duties and have direct contact with the chemical, while ONUs work in the general vicinity of workers but do not handle 1,3-butadiene and do not have direct contact with the 1,3-butadiene being handled by the

workers. EPA evaluated inhalation exposures to both workers and ONUs.

Due to the volatility and transport methods of 1,3-butadiene, EPA did not evaluate routine dermal exposure to workers. 1,3-Butadiene is typically transported in a liquefied form by condensing the gaseous form under high pressure. Rapid evaporation of a liquid from a pressurized system will likely cause frostbite if it contacts the skin. Due to the severity of this hazard, it is not expected that dermal exposure to 1,3-butadiene would regularly occur (EPA-HQ-OPPT-2018-0451-0038).

2 APPROACH AND METHODOLOGY

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

- **Process Description:** A description of the OES, including the function of the chemical in the OES; physical forms and weight fractions of the chemical throughout the process; the total PV associated with the OES; per site throughputs/use rates of the chemical; operating schedules; and process vessels, equipment, and tools used during the condition of use.
- **Estimates of Number of Facilities:** An estimate of the number of sites that use 1,3-butadiene for the given OES.
- **Environmental Release Sources:** A description of each of the potential sources of environmental releases to air in the process for the given OES.
- **Environmental Release Assessment Results:** Estimates of chemical released into each environmental media (surface water, POTW, non-POTW WWT, fugitive air, stack air, and land disposal).
- **Worker Activities:** A description of the worker activities, including an assessment for potential points of worker and ONU exposure.
- **Number of Workers and ONU:** 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 ONU. See Section 2.4.3 for a discussion of EPA's statistical analysis approach for assessing inhalation exposure.

For the remainder of this section, the approach and methodology for completing each of the above listed components is described in more detail.

2.1 Process Descriptions

EPA performed a literature search to find descriptions of processes involved in each OES. Where data were available to do so, the Agency included the following information in each process description:

- Total PV associated with the OES;
- Name and location of sites where the OES occurs;
- Facility operating schedules (*e.g.*, year-round, 5 days/week, batch process, continuous process, multiple shifts)
- Key process steps;
- Physical form and weight fraction of the chemical throughout the process steps;
- Information on receiving and shipping containers; and
- Ultimate destination of chemical leaving the facility.

Where 1,3-butadiene-specific process descriptions were unclear or not available, EPA referenced generic process descriptions from literature, including relevant Emission Scenario Documents (ESD) or Generic Scenarios (GS). Process descriptions for each OES can be found in Section 3.

2.2 Number of Facilities

To estimate the number of facilities within each OES, EPA used a combination of bottom-up analyses of EPA reporting programs and top-down analyses of U.S. economic data and industry-specific data. Generally, EPA used the following steps to develop facility estimates:

1. Identify or "map" each facility reporting for 1,3-butadiene in the 2016 and 2020 CDR (U.S. EPA, 2020b, 2016), 2016-2021 TRI (U.S. EPA, 2021b), and 2017 and 2020 NEI (U.S. EPA, 2019b) to an OES. The full details of the methodology for mapping facilities from EPA reporting programs is described in Appendix F. In brief, mapping consists of using facility reported industry sectors (typically reported as either North American Industry Classification System (NAICS) or Standard Industrial Classification (SIC) codes), and chemical activity, processing, and use information to assign the most likely OES to each facility.
2. Based on the reporting thresholds and requirements of each dataset, evaluate whether the data in the reporting programs are expected to cover most or all the facilities within the OES. If so, no further action was required, and EPA assessed the total number of facilities in the OES as equal to the count of facilities mapped to the OES from each dataset. If not, EPA proceeded to Step 3. All OESs with quantified releases and exposures except for one obtained the number of facilities solely from reporting programs. See the *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of this count. For Application of Adhesives and Sealants, with only one reporting site, EPA proceeded to Step 3 and 4.
3. Supplement the available reporting data with U.S. economic and market data using the following method:
    a. Identify the NAICS codes for the industry sectors associated with the OES.
    b. Estimate total number of facilities using the U.S. Census' Statistics of US Businesses (SUSB) data on total establishments by 6-digit NAICS.
    c. Use market penetration data to estimate the percentage of establishments likely to be using 1,3-butadiene instead of other chemicals.
    d. Combine the data generated in Steps 3.a through 3.c to produce an estimate of the number of facilities using 1,3-butadiene in each 6-digit NAICS code and sum across all applicable NAICS codes for the OES to arrive at a total estimate of the number of facilities within the OES. Typically, EPA assumed this estimate encompasses the facilities identified in Step 1; therefore, EPA assessed the total number of facilities for the OES as the total generated from this analysis.
4. If market penetration data required for Step 3.c. are not available, use generic industry data from GSs, ESDs, and other literature sources on typical throughputs/use rates, operating schedules, and the 1,3-butadiene PV used within the OES to estimate the number of facilities. In cases where EPA identified a range of operating data in the literature for an OES, EPA used stochastic modeling to provide a range of estimates for the number of facilities within an OES. EPA provided the details of the approaches, equations, and input parameters used in stochastic modeling in the relevant OES sections throughout this report.

2.3 Environmental Releases Approach and Methodology

Releases to the environment are a component of potential exposure and may be derived from reported data that are obtained through direct measurement via monitoring, calculations based on empirical data, and/or assumptions and models. For each OES, EPA, where possible, provided annual releases, high-end and central tendency daily releases, and the number of release days per year for each media of release (air, water, and land).

EPA used the following hierarchy in selecting data and approaches for assessing environmental releases:

1. Monitoring and measured data:

   a. Releases calculated from site-specific concentration in medium and flow rate data
   b. Releases calculated from mass balances or emission factor methods using site-specific measured data
2. Modeling approaches:
   a. Surrogate or analogous release data
   b. Fundamental modeling approaches
   c. Statistical regression modeling approaches
3. Release limits:
   a. Company-specific limits
   b. Regulatory limits (*e.g.*, National Emission Standards for Hazardous Air Pollutants [NESHAPs] or effluent limitations/requirements)

EPA's preference was to rely on facility-specific release data reported in TRI (U.S. EPA, 2021b) and NEI (U.S. EPA, 2019b), where available. For 1,3-butadiene, monitored and measured data from TRI and NEI provided release estimates for every OES except one—Application of adhesives and sealants—which used the relevant ESD and modeling. Specific details related to the use of release data or models for each OES can be found in Section 3. With release estimates identified for all OESs through the use of monitoring data and modeling, release limits were not used in this assessment.

The final release results may be described as 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 release result:

- **Deterministic calculations**: EPA used combinations of point estimates of each input parameter to estimate a central tendency and high-end for each final release result. The Agency documented the method and rationale for selecting parametric combinations to be representative of central tendency and high-end in the relevant OES subsections in Section 3. In general, central tendency is calculated as the 50th percentile of the releases reported to the OES, and high end is the 95th percentile. Calculations for these results can be found in the Supplemental Release Files.
- **Probabilistic (stochastic) calculations**: EPA used Monte Carlo simulations using the full distribution of each input parameter to calculate a full distribution of the final release 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, EPA used Monte Carlo modeling to estimate annual throughputs and PV, but only had point estimates of release timing. In this case, EPA documented the approach and rationale for combining point estimates with distribution results for estimating central tendency and high-end results in the relevant OES subsections in Section 3.

2.3.1 Identifying Release Sources

EPA performed a literature search to identify process operations that could potentially result in releases of 1,3-butadiene to air, water, or land from each OES. For each OES, EPA identified the release sources and the associated media of release. Where 1,3-butadiene release sources were unclear or not available, EPA referenced relevant ESD's or GS's. Descriptions of release sources for each OES can be found in Section 3.

2.3.2 Estimating Release Days per Year

EPA typically assumed the number of release days per year from any release source will be equal to the number of operating days at the facility unless information is available to indicate otherwise. To

estimate the number of operating days, EPA used the following hierarchy:

1. **Facility-specific data:** EPA used facility-specific operating days per year data if available. If facility-specific data was not available for one facility of interest but was available for other facilities within the same OES, EPA estimated the operating days per year using one of the following approaches:
    a. If other facilities have known or estimated average daily use rates, EPA calculated the days per year as: Days/year = Estimated Annual Use Rate for the facility (kg/year) / average daily use rate from facilities with available data (kg/day).
    b. If facilities with days per year data do not have known or estimate average daily use rates, EPA used the average number of days per year from the facilities with such data available.
2. **Industry-specific data:** EPA used industry-specific data available from GSs, ESDs, trade publications, or other relevant literature.
3. **Manufacture of large-PV commodity chemicals:** Commodity chemicals are basic and relatively inexpensive compounds that are often produced in large quantities at plants built specifically to make one chemical. These plants are often run continuously, typically only shutting down for a few weeks a year for maintenance. Because of this, for the manufacture of the large-PV commodity chemicals, EPA used a value of 350 days per year. This assumes the plant runs seven days per week and 50 weeks per year (with 2 weeks down for turnaround) and assumes that the plant is always producing the chemical.
4. **Manufacture of lower-PV specialty chemicals:** Specialty chemicals are often more expensive and are produced less frequently, at smaller quantities, and on an "as needed" basis. Because of this, for the manufacture of lower-PV specialty chemicals, it is unlikely the chemical is being manufactured continuously throughout the year. Therefore, EPA used a value of 250 days per year. This assumes the plant manufactures the chemical five days per week and 50 weeks per year (with 2 weeks down for turnaround).
5. **Processing as reactant (intermediate use) in the manufacture of commodity chemicals:** Similar to #3, EPA assumed the manufacture of commodity chemicals occurs 350 days per year such that the use of a chemical as a reactant to manufacture a commodity chemical would also occur 350 days per year.
6. **Processing as reactant (intermediate use) in the manufacture of specialty chemicals:** Similar to #4, the manufacture of specialty chemicals is not likely to occur continuously throughout the year. Therefore, EPA used a value of 250 days per year.
7. **Other Chemical Plant OESs (*e.g.*, processing into formulation and use of industrial processing aids):** For these OESs, EPA assumed that the chemical of interest is not always in use at the facility, even if the facility operates 24/7. Therefore, in general, EPA used a value of 300 days/year based on the "SpERC fact sheet – Formulation & (re)packing of substances and mixtures – Industrial (Solvent-borne)" which uses a default of 300 days/year for the chemical industry (ESIG, 2012). However, in instances where the OES uses a low volume of the chemical of interest, EPA used 250 days per year as a lower estimate.
8. **POTWs:** Although EPA expects POTWs to operate continuously over 365 days per year, the discharge frequency of the chemical of interest from a POTW will be dependent on the discharge patterns of the chemical from the upstream facilities discharging to the POTW. However, there can be multiple upstream facilities (possibly with different OESs) discharging to the same

POTW and information to determine when the discharges from each facility occur on the same day or separate days is typically not available. Therefore, EPA could not determine an exact number of days per year the chemical of interest is discharged from the POTW and used a value of 365 days per year.

9. **All Other OESs:** Regardless of what the facility operating schedule is, other OESs are unlikely to use the chemical of interest every day. Therefore, EPA used a value of 250 days per year for these OESs.

2.3.3 Estimating Releases from Data Reported to EPA

Generally, EPA used the facility-specific release data reported in TRI, DMR, and NEI as annual releases in each dataset for each site and estimated the daily release by averaging the annual release over the expected release days per year. EPA's approach to estimating release days per year is described in Section 2.3.2. The relevant supplemental files contain the calculations of the central tendency and high-end annual and daily releases for each OES that used EPA databases to estimate releases. Land release calculations are in *Draft Land Releases for 1,3-Butadiene* (U.S. EPA, 2024f). Water release calculations are in *Draft Water Releases for 1,3-Butadiene* (U.S. EPA, 2024l). Air release calculations using TRI are in *Draft Air Releases (TRI) for 1,3-Butadiene* (U.S. EPA, 2024d). Air release calculations using NEI, all annual and daily calculations from both years (2017 and 2020) are in *Draft Air Releases (NEI2017) for 1,3-Butadiene* (U.S. EPA, 2024b). The raw release data from NEI 2020 are in the *Draft Air Releases (NEI2020) for 1,3-Butadiene* (U.S. EPA, 2024c).

TRI

Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) established the TRI. TRI tracks the waste management of designated toxic chemicals from facilities within certain industry sectors. Facilities are required to report to TRI if the facility has 10 or more full-time employees; is included in an applicable NAICS code; and manufactures, processes, or uses the chemical in quantities greater than a certain threshold (25,000 lb for manufacturers and processors and 10,000 lb for users of 1,3-butadiene). Facilities provide on-site release information using readily available data (including monitoring data) collected pursuant to other provisions of law, or, where such data are not readily available, "reasonable estimates" of the amounts released. EPA makes the reported information publicly available through TRI.

Each facility subject to the rule must report either using a Form R or a Form A. Facilities reporting using a Form R must report annually the volume of chemical released to the environment (*i.e.*, surface water, air, or land) and/or managed through recycling, energy recovery, and treatment (*e.g.*, incineration) from the facility. Facilities may submit a Form A if the volume of chemical manufactured, processed, or otherwise used does not exceed 1,000,000 pounds per year (lb/year) and the total annual reportable releases do not exceed 500 lb/year. Facilities reporting using a Form A are not required to submit annual release and waste management volumes or use/sub-use information for the chemical. Due to reporting limitations, some sites that manufacture, process, or use 1,3-butadiene may not report to TRI and are therefore not included in EPA's assessment.

For each release quantity reported, TRI filers select a "basis of estimate" code to indicate the principal method used to determine the release quantity. TRI provides six basis of estimate codes, which in no particular order, are continuous monitoring, periodic monitoring, mass balance calculations, published emission factors, site-specific emission factors, and engineering calculations/best engineering judgment. For facilities that use a TRI chemical in multiple operations, the filer may use a combination of methods to calculate the overall release quantity. In such cases, TRI instructs the facility to enter the basis of

estimate code for the method that corresponds to the largest portion of the reported release quantity.[1] Additional details on the basis for the reported release estimate (*e.g.*, calculations, underlying assumptions) are not reported in TRI.

EPA included both TRI Form R and Form A submissions in the analysis of environmental releases. For Form Rs, EPA assessed releases using the reported annual release volumes from each media. For Form As, EPA assessed releases using the 500 lb per year threshold for each release media; however, since this threshold is for total site releases, the 500 lb/year is attributed to one release media—not all (to avoid over counting the releases and exceeding the total release threshold for Form A). For this risk evaluation, EPA used TRI data from reporting years 2016-2021 to provide a basis for estimating releases (U.S. EPA, 2021b). Further details on EPA's approach to using TRI data for estimating releases are described in Section 2.3.3.1, Appendix F, and 7F.1.

EPA obtained 2016 to 2021 TRI data for 1,3-butadiene from EPA's Basic Plus Data Files. The Agency followed a similar approach to estimate air, water, and land releases. EPA used the reported annual releases directly as reported in TRI and then divided the annual releases over the number of estimated operating days to obtain daily average release estimates. EPA presents the release data as high-end and central tendency estimates by calculating the 50th and 95th percentiles of the releases from all facilities mapped to a given OES. Release estimates are separated where relevant by stack and fugitive air emissions, surface water discharges, POTWs, non-POTW WWT, and land releases.

- Air emissions in TRI are reported separately for stack air and fugitive air and occur on-site at the facility. From 2016 to 2021, 288 facilities reported air emissions of 1,3-butadiene, and there were 1169 total reports.
- Water releases in TRI include both reports of annual direct discharges to surface water and annual indirect discharges to off-site POTWs and wastewater treatment (WWT) facilities. A total of 31 facilities reported water releases of 1,3-butadiene, with a total of 114 reports over the 6 years that were assessed.
- Land releases in TRI provide the type of release media for a particular facility, as well as how the chemical is managed through recycling, energy recovery, or treatment. A total of 39 facilities reported land releases of 1,3-butadiene.

NEI

The NEI was established to track emissions of Criteria Air Pollutants (CAPs) and CAP precursors and assist with National Ambient Air Quality Standard (NAAQS) compliance under the CAA. Air emissions data for the NEI are collected at the state, local, and tribal (SLT) level. SLT air agencies then submit these data to EPA through the Emissions Inventory System (EIS). In addition to CAP data, many SLT air agencies voluntarily submit data for pollutants on EPA's list of HAPs. EPA uses the data collected from SLT air agencies, in conjunction with supplemental HAP data, to build the NEI. The Agency makes an updated NEI publicly available every three years. For this risk evaluation, EPA used NEI data for reporting years 2017 and 2020 data to provide a basis for estimating releases. (U.S. EPA, 2019b)

NEI emissions data is categorized into (1) point source data, (2) area or nonpoint source data, (3) onroad mobile source data, and (4) nonroad mobile source data. EPA included only point source data categories in the assessment of environmental releases in this risk evaluation (see Appendix G.2.1 for more information on area or nonpoint and onroad mobile sources). Point sources are stationary sources of air emissions from facilities with operating permits under Title V of the CAA, also called "major sources."

[1] See TRI Program Guidance on EPA's GuideME website under Reporting Forms and Instructions, Section 5. Quantity of the Toxic Chemical Entering Each Environmental Medium On-Site (Form R).

Major sources are defined as having actual or potential emissions at or above the major source thresholds. While thresholds can vary for certain chemicals in NAAQS non-attainment areas, the default threshold is 100 tons/year for non-HAPs, 10 tons per year for a single HAP, or 25 tons per year for any combination of HAPs. Point source facilities include large energy and industrial sites and are reported at the emission unit- and release point-level. Further details on EPA's approach to using NEI data for estimating releases are described in Section 2.3.3.2, Appendix F, and F.1.

Where available, EPA used NEI data to estimate annual and average daily fugitive and stack air emissions. Facility-level annual emissions are available for major sources in NEI. EPA then divided the annual stack and fugitive emissions over the number of estimated operating days to develop daily release estimates. In some cases, the same facility reported air releases to both TRI and NEI for a given reporting year. EPA presented data from both sources for the air release assessment.

- In 2017, there were 735 facilities that reported point source air emissions of 1,3-butadiene to NEI and 5,120 point source reports.
- In 2020, there were 713 facilities that reported point source air emissions to NEI and 5,346 point source reports.

DMR

There was no reported release of 1,3-butadiene submitted to DMR for the years of this assessment (2016–2021) and so DMR data were not included in the assessment of environmental releases in this draft risk evaluation.

2.3.3.1 Estimating Wastewater Discharges from TRI

Where available, EPA used TRI to estimate annual wastewater discharges, average daily wastewater discharges, and high-end daily wastewater discharges. Water releases in TRI include both reports of annual direct discharges to surface water and annual indirect discharges to off-site POTWs and WWT facilities. Direct discharges to surface water and indirect discharges to off-site POTWs and WWT facilities from TRI were assessed. Although surface water discharges are released to the environment, discharges to POTWs and WWT facilities are not directly released into the environment, but to treatment facilities.

Annual Wastewater Discharges

For TRI, annual discharges are reported directly by facilities.

Average Daily Wastewater Discharges

To estimate average daily discharges, EPA used the following steps:

1. Obtained reported annual direct surface water discharges and indirect discharges to POTW and non-POTW WWT in TRI. Although all data is obtained, only direct discharges were included in the analysis.
2. For TRI reporters using Form A releases are not provided. EPA estimated annual releases using the threshold of 500 lb per year.
3. Divided the annual discharges over the number of estimated operating days (estimated as described in Section 2.3.2).
4. Estimated a release duration using facility-specific data available in models and/or literature sources. If no data was available, listed as "unknown".

2.3.3.2 Estimating Air Emissions from TRI and NEI

Where available, EPA used TRI and NEI data to estimate annual and average daily fugitive and stack air

emissions. For air emissions, EPA estimated both release patterns (*i.e.*, days per year of release) and release durations (*i.e.*, hours per day the release occurs).

Annual Emissions

Facility-level annual emissions are available for TRI reporters and major sources in NEI. EPA used the reported annual emissions directly as reported in TRI and NEI for major sources.

Average Daily Emissions

To estimate average daily emissions for TRI reporters and major sources in NEI, EPA used the following steps:

1. Obtain total annual fugitive and stack emissions for each TRI reporter and point sources in NEI.
2. For TRI reporters using a Form A, estimate annual releases using the threshold of 500 lb per year.
3. Divide the annual stack and fugitive emissions over the number of estimated operating days (note: NEI data includes operating schedules for many facilities that can be used to estimate facility-specific days per year).
4. Estimate a release duration using facility-specific data available in NEI, models, and/or literature sources. If no data is available, list as "unknown."

2.3.3.3 Estimating Land Releases from TRI

Where available, EPA used TRI data to estimate annual and average daily land disposal volumes. TRI includes reporting of disposal volumes for a variety of land disposal methods, including underground injection, RCRA Subtitle C landfills, land treatment, RCRA Subtitle C surface impoundments, other surface impoundments, and other land disposal. TRI also provides the type of release media for a particular facility, as well as how the chemical is managed through recycling, energy recovery, or treatment. EPA provided estimates for the total aggregated land disposal volume.

Annual Land Disposal

Facility-level annual disposal volumes are available directly for TRI reporters. EPA used the reported annual land disposal volumes directly as reported in TRI for each land disposal method. The Agency combined totals from all land disposal methods from each facility to estimate a total annual aggregate disposal volume to land.

Average Daily Land Disposal

To estimate average daily disposal volumes, EPA used the following steps:

1. Obtain total annual disposal volumes for each land disposal method for each TRI reporter.
2. For TRI reporters using a Form A, estimate annual releases using the threshold of 500 lb per year.
3. Divide the annual disposal volumes for each land disposal method over the number of estimated operating days.

2.3.4 Estimating Releases from Models

Where releases were expected for an OES but TRI and/or NEI data were not available or where EPA determined they did not capture the entirety of environmental releases for an OES, the Agency utilized models to estimate environmental releases. 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 releases, EPA followed these steps to estimate releases:

1. Identify release sources from process and associated release media.
2. Identify or develop model equations for estimating releases from each release source.
3. Identify model input parameter values from relevant literature sources.
4. If a range of input values is available for an input parameter, determine the associated distribution of input values.
5. Calculate annual and daily release volumes for each release source using input values and model equations.
6. Aggregate release volumes by release media and report total releases to each media from each facility.

For release models that utilized stochastic calculations, EPA performed a Monte Carlo simulation using the Palisade @Risk software[2] with 100,000 iterations and the Latin Hypercube sampling method. Detailed descriptions of the model approaches used for the relevant OESs, model equations, input parameter values and associated distributions are provided in Appendix D.

EPA used models to estimate environmental releases in one case—the OES Application of adhesives and sealants. See Section 3.10 for more detail on this scenario and the *Draft Adhesives and Sealants Release Model for 1,3-Butadiene* (U.S. EPA, 2024a), detailing the calculations. All other releases were estimated using data reported to EPA as described in Section 2.3.3.

2.4 Occupational Exposure Approach and Methodology

For workplace exposures, EPA considered exposures to both workers who directly handle 1,3-butadiene and ONUs who do not directly handle 1,3-butadiene but may be exposed to vapors, particulates, or mists that enter their breathing zone while working in locations in close proximity to 1,3-butadiene. EPA evaluated inhalation exposures to both workers and ONUs. Note that the Agency's estimates of occupational exposure presented in this assessment do not assume the use of PPE; however, the effect of respiratory protection fit factors on EPA's occupational exposure estimates can be explored in the *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2024i). For more discussion on respiratory protection and glove protection, refer to Appendix E.

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 1,3-butadiene. There is potential for exposure to workers and/or ONUs via inhalation of vapor due to the activities and uses of 1,3-butadiene. Exposure may occur due to fugitive emissions present during activities such as the manufacture and processing of 1,3-butadiene, or may occur due to uses of 1,3-butadiene such as use as a laboratory chemical or the application of an adhesive or sealant containing 1,3-butadiene. EPA expects inhalation to be the primary route of exposure, and dermal exposure to liquid 1,3-butadiene is not expected, as discussed in Section 1.2.

[2] This software can be acquired from the following: *@Risk*; Palisade; https://www.palisade.com/risk/.

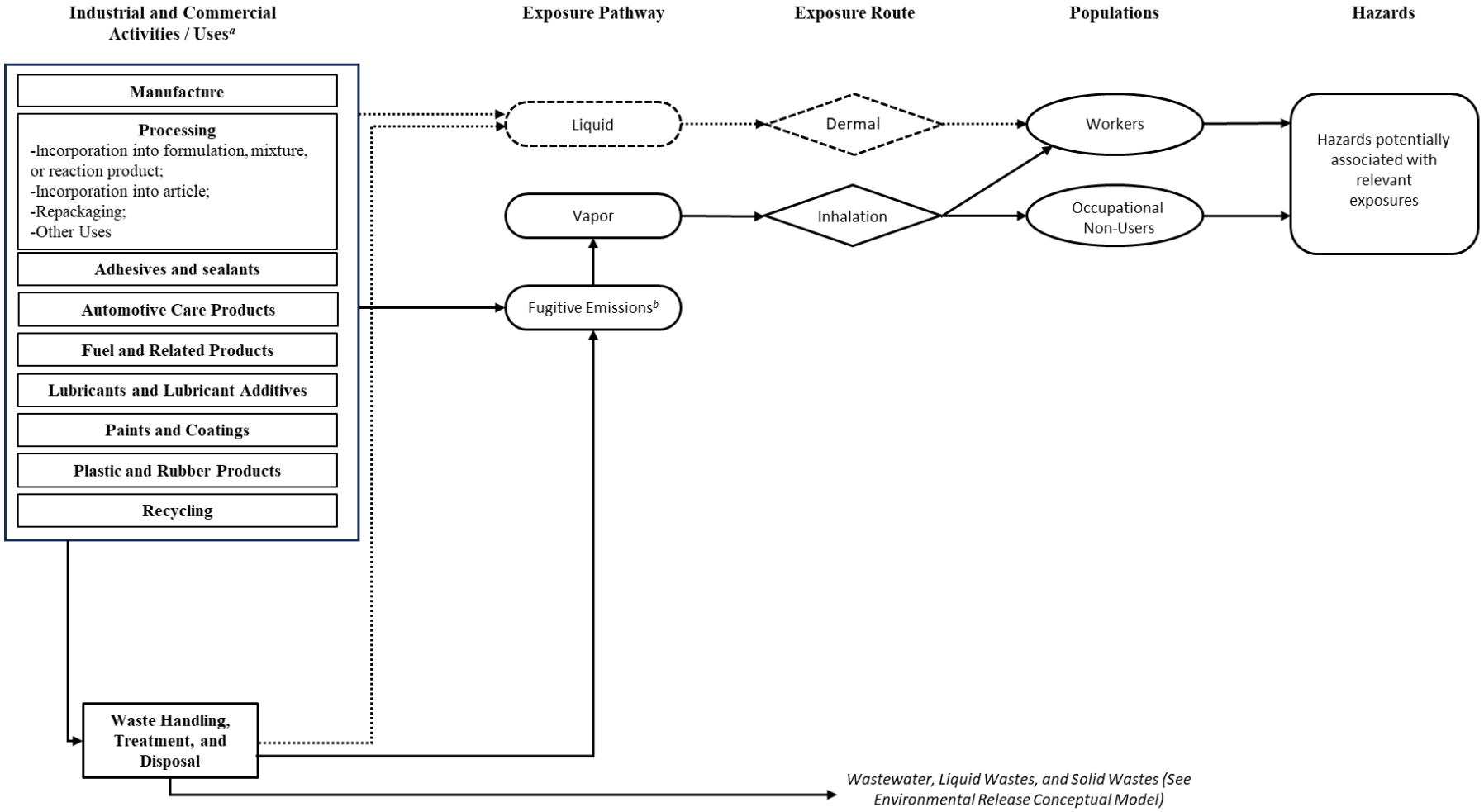


Figure 2-1. 1,3-Butadiene Conceptual Model for Industrial and Commercial Activities and Uses: Potential Exposure and Hazards

[a] "Industrial use" means use at a site at which one or more chemicals or mixtures are manufactured (including imported) or processed, and "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.

[b] 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.

EPA provided occupational inhalation exposure results representative of *central tendency* conditions *and high-end* conditions. A central tendency is assumed to be representative of occupational exposures in the center of the distribution for a given condition of use. For 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. EPA's preference is to use the 50th percentile of the distribution. However, if the full distribution is not known, the Agency 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, 1992). For risk evaluation, EPA used 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, where possible, EPA provided high-end and central tendency full-shift time-weighted average (TWA) (typically as 8-hour TWA) inhalation exposure concentrations. The Agency follows 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:
    a. Company-specific occupational exposure limits (OELs) (for site-specific exposure assessments, *e.g.*, 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 (PEL)
    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])

EPA used the estimated high-end and central tendency full-shift TWA inhalation exposure concentrations 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). Relevant equations and sample calculations can be found in 7B.1. The approach to estimating each exposure metric is described in Section 2.4.4.

For 1,3-butadiene, EPA calculated the estimated high-end and central tendency full-shift TWA inhalation exposure concentrations using discrete inhalation data directly relevant to each OES. In a few

cases, described in the sections that follow, inhalation data from different OESs are used as analog. This means that, though there may have been no 1,3-butadiene data directly applicable to some OESs, there was 1,3-butadiene data for a similar occupational scenario that could be used as a substitute. Since monitoring data was identified as being relevant to the applicable OESs, no fundamental or statistical regression modeling approaches were used in this assessment to estimate inhalation exposure, nor were occupational exposure limits.

Dermal exposure was not assessed for 1,3-butadiene due to the volatility and transport method of the chemical. See Section 1.2 for further information.

See *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2024i), "Inhalation Exposure" tab, for a summary of the inhalation data used in this assessment.

2.4.1 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, EPA referenced relevant ESDs or GSs. Worker activities for each OES can be found in Section 3.

2.4.2 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 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 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 1,3-butadiene 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, DMR and/or 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 1,3-butadiene in each industry/occupation combination and sum these to arrive at a total estimate of the number of employees with exposure within the condition of use.

There are uncertainties surrounding the estimated number of workers potentially exposed to 1,3-butadiene. 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 1,3-butadiene 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 1,3-butadiene 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 1,3-butadiene is used in each industry. The designations of which industries and occupations have potential exposures is a matter of professional judgement; 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.

2.4.3 Estimating Inhalation Exposures

2.4.3.1 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 public comments. Studies were evaluated using the evaluation strategies laid out in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances* (U.S. EPA, 2021a).

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 percentile and 95th percentile. 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, data sets with only a single 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* (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 may handle 1,3-butadiene and have direct contact with the chemical, while ONUs are working in the general vicinity of workers but do not handle 1,3-butadiene and do not have direct contact with 1,3-butadiene being handled by the workers. 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 is 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 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 1,3-butadiene 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, 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 online Chemical Exposure Health Database (CEHD). 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 PEL. 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. **Download data for 1,3-butadiene between the years 2000 and 2020 in the CEHD.** This timeframe was chosen due to the changing of the OSHA PEL for 1,3-butadiene from 1,000 ppm 8-hour TWA to 1 ppm that occurred in 1997, with an implementation period that ended in November 1999.
2. **Organize data by site** (group data collected at the same site together).
3. **Remove data in which all measurements taken at the site were recorded as "0" or below the limit of detection (LOD)** as EPA could not be certain the chemical of interest was at the site at the time of the inspection (Note that sites where bulk samples were collected that indicate 1,3-butadiene was present were not removed from the data set.)

4. **Remove serum samples, bulk samples, wipe samples, and blanks.** These data are not used in EPA's assessment.
5. **Assign each data point to an OES.** Review 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. **Combine 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. **Address 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 is 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. **Calculate 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.

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

2.4.3.2 Inhalation Exposure Modeling

Where inhalation exposures are expected for an OES but monitoring data were not available, EPA utilized analogous monitoring data, which is monitoring data of the same chemical but for a different (ideally similar) activity, to estimate occupational exposure to 1,3-butadiene.

2.4.4 Estimating Acute, Intermediate, and Chronic (Non-cancer and Cancer) Exposures

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

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

2.5 Evidence Integration for Environmental Releases and Occupational Exposures

Evidence integration for the environmental release and occupational exposure assessment includes analysis, synthesis and integration of information and data to produce estimates of environmental releases and occupational inhalation exposures. During evidence integration, EPA considered the likely location, duration, intensity, frequency, and quantity of releases and exposures while also considering factors that increase or decrease the strength of evidence when analyzing and integrating the data. 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 in exposure evidence integration. 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 data set 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 environmental releases and occupational exposures resulting directly from a specific source, medium, or product. If available, measured release and 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, the Agency may have given preference to high quality modeled data directly applicable to the OES being assessed over low quality measured data that is not specific to the OES. The final integration of the environmental release and occupational exposure evidence combined decisions regarding the strength of the available information, including information on plausibility and coherence across each evidence stream.

3 ENVIRONMENTAL RELEASE AND OCCUPATIONAL EXPOSURES ASSESSMENTS 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, release sources, media of release, and release assessment approach and results) for the assessment of each OES.

Refer to Table 1-1 to see how each OES described below pairs with the COU stated in the final scope for 1,3-butadiene, published by EPA in August 2020 (U.S. EPA, 2020c).

For all cases except for Application of Adhesives and Sealants (which utilized release modeling), the annual and daily central tendencies and high ends for releases can be found in the following locations:

- For surface water, POTW, and WWT releases (where applicable), see the "OES-Direct", "OES-Indirect POTW", or "OES-Indirect WWT" tabs, respectively, in *Draft Water Releases for 1,3-Butadiene* (U.S. EPA, 2024l).
- For stack and fugitive air releases from TRI, see the "OES Summary" tab in *Draft Air Releases (TRI) for 1,3-Butadiene* (U.S. EPA, 2024d).
- For stack and fugitive air releases from NEI, see the "OES Summary" tab in *Draft Air Releases (NEI2017) for 1,3-Butadiene* (U.S. EPA, 2024b). This spreadsheet contains calculations for both years of NEI data. To see the raw release data used in the assessment from the 2020 NEI, see *Draft Air Releases (NEI2020) for 1,3-Butadiene* (U.S. EPA, 2024c).
- For land releases, see the "OES Summary" tab of *Draft Land Releases for 1,3-Butadiene* (U.S. EPA, 2024f).

For the Application of Adhesives and Sealants release model, see the *Draft Adhesives and Sealants Release Model for 1,3-Butadiene* (U.S. EPA, 2024a).

For the central tendencies and high ends for occupational exposure tables, see the "Inhalation Data" tab in the *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2024i)

3.1 Manufacturing

3.1.1 Process Description

The final scope for 1,3-butadiene lists domestic manufacturing as an in-scope condition of use (U.S. EPA, 2020c). 1,3-Butadiene can be produced by three processes—steam cracking of paraffinic hydrocarbons (the ethylene coproduct process), catalytic dehydrogenation of n-butane and n-butene (the Houndry process), and oxidative dehydrogenation of n-butene (the Oxo-D or O-X-D process). The predominant method of the three processes is the steam cracking process, which accounts for greater than 91 percent of the world's butadiene supply (EPA-HQ-OPPT-2018-0451-0021). These manufacturing processes are performed in closed systems.

The ethylene coproduct process can use a variety of hydrocarbon feedstocks, the heavier fractions generally giving a higher 1,3-butadiene yield per amount of ethylene produced (Miller and Villaume, 1978). In this production process, the hydrocarbon feedstock is fed to a pyrolysis (steam cracking) furnace where it is heated to temperatures between approximately 1,450 and 1,525 °F (790–830 °C). Within this temperature range, the feedstock molecules "crack" to produce a variety of co-products including butadiene. After the pyrolysis reaction is quenched and additional refinery steps, a mixed C_4 hydrocarbon stream is obtained. Figure 3-1 provides an example process flow diagram of the ethylene coproduct process to manufacture 1,3-butadiene.

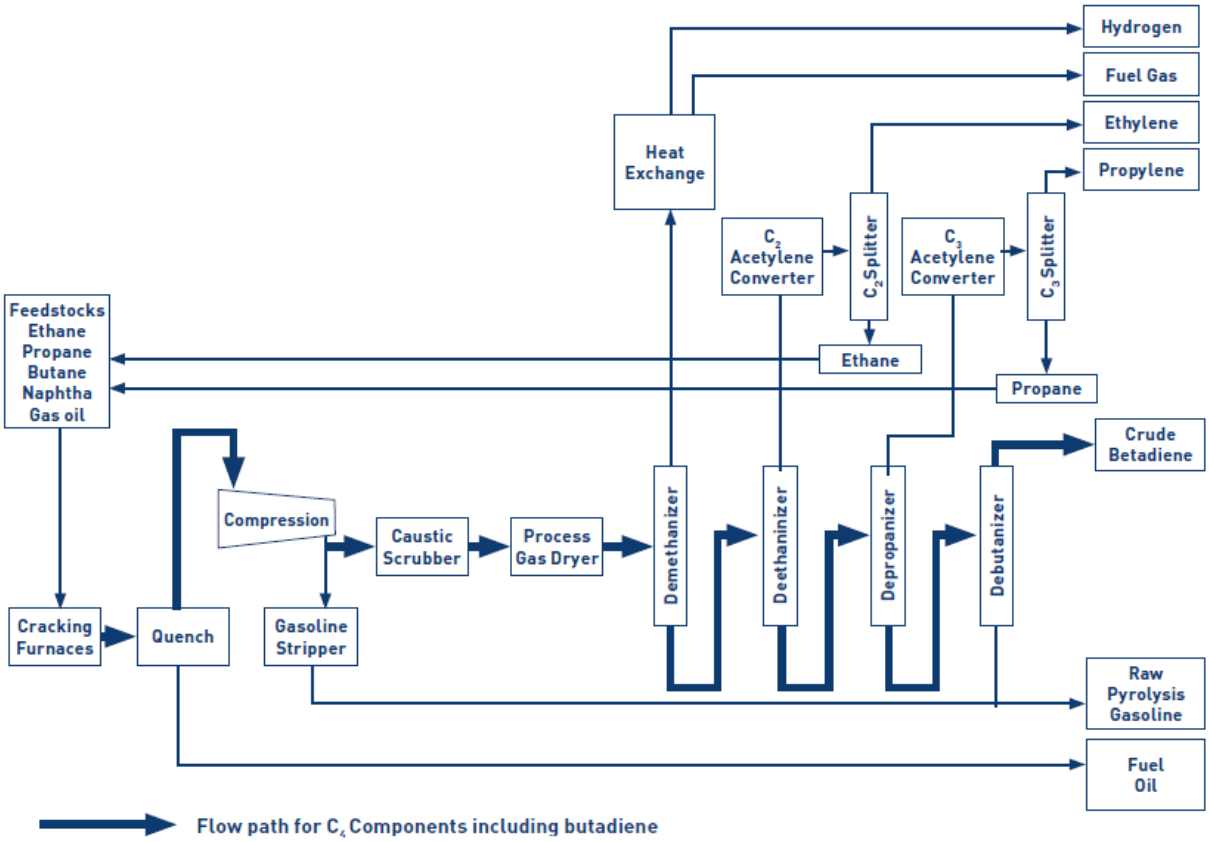


Figure 3-1. Process Flow Diagram for the Manufacture of 1,3-Butadiene in a Typical Olefins Plant
Source: ACC (EPA-HQ-OPPT-2018-0451-0041)

In the Houdry process, n-butane is dehydrogenated over chromium/alumina catalysts. Several packed-bed reactors, arranged parallel to each other, are operated alternatingly (Grub and Löser, 2011). The reactors normally operate at 12 to 15 cm Hg absolute pressure and approximately 1,100 to 1,260 °F (600–680 °C). Three or more reactors can be used in this process to simulate continuous operation: while the first reactor is on-line, the second is being regenerated, and the third is being purged prior to regeneration. Residence time for feed in the reactor is approximately 5 to 15 minutes. As the endothermic reaction proceeds, the temperature of the catalyst bed decreases, and a small amount of coke is deposited. In the regeneration cycle, this coke is burned with preheated air, which can supply essentially all the heat required to bring the reactor up to the desired reaction temperature. The reactor effluent goes directly to a quench tower, where it is cooled. This stream is compressed before feeding an absorber/stripper system, where a C4 concentrate is produced to be fed to a butadiene extraction system for the recovery of high purity butadiene (EPA-HQ-OPPT-2018-0451-0021).

The Oxo-D process most often uses n-butene as feedstock due to its greater reactivity, which results in the same amount of product produced under less severe operating conditions when compared to n-butane, though processes and catalyst systems have been developed for both. In general, in an oxydehydrogenation process, a mixture of n-butenes, air and steam is passed over a catalyst bed generally at low pressure and approximately 930 to 1,110 °F (500–600 °C). The heat from the exothermic reaction can be removed by circulating molten heat transfer salt, or by using the stream externally for steam generation. An alternate method is to add steam to the feed to act as a heat sink. The heat can then be recovered from the reactor effluent. After the reactor effluent is cooled, the C_4

components are recovered in an absorber/degasser/stripper column combination. The lean oil flows from the bottom of the stripper back to the absorber, with a small amount passing through a solvent purification area. Crude butadiene is stripped from the oil, recovered in the overhead of the stripper, then it is sent to a purification system to recover the butadiene product. Reaction yields can range from 70 to 90 percent, making it unnecessary to recover and recycle feedstock (yield losses can produce the CO_2) (EPA-HQ-OPPT-2018-0451-0021). The advantages of this method are the low consumption of steam and heating energy, high conversion and selectivity per reactor cycle, longer life span of the catalyst, and no requirement for catalyst regeneration (Grub and Löser, 2011).

Each of these processes produces a stream commonly referred to as crude butadiene that has a 1,3-butadiene content as high as 75 percent (EPA-HQ-OPPT-2018-0451-0004, EPA-HQ-OPPT-2018-0451-0021). Separation and purification of the butadiene stream is typically carried out by extractive distillation since the boiling points of the various C_4 components are so close to each other that 1,3-butadiene cannot normally be obtained from the mixed C_4-stream by simple distillation. In this process, a polar solvent (*e.g.*, furfural, acetonitrile, cuprous ammonium acetate, dimethylformamide, a furfuralmethoxypropionitrile system, dimethylacetamide or n-methylpyrrolidone) is added to change the relative volatilities of the components of the mixture (IARC, 1986; Peterson et al., 1980; Miller and Villaume, 1978). The final concentration in the purified butadiene product is typically less than 99 weight percent pure and is stored liquefied in a pressurized sphere (ToxStrategies, 2021).

1,3-Butadiene is manufactured as a liquid and stored in a pressurized container. The product is expected to be repackaged and/or sent for processing as a reactant, rubber compounding, or incorporation into a formulation, mixture, or reaction product. 1,3-Butadiene is produced as reagent grade, 99.5 percent or higher purity with permitted impurity levels of 1,2-butadiene, acetylenes, water, and C_5s specified by the company (Sun and Wristers, 2002).

3.1.2 Facility Estimates

The 2020 CDR estimates 13 sites domestically manufacturing 1,3-butadiene (U.S. EPA, 2020b). However, using TRI and NEI to supplement the data from CDR, EPA identified 63 manufacturing facilities in total. Many of these additional facilities are due to TRI facilities that report the manufacture of 1,3-butadiene as a byproduct. Facilities may report to multiple databases under different names, and in these cases, EPA used reported addresses and company information to match facilities with their equivalents across databases but note that there is some uncertainty to the facility estimate due to this.

Facilities that produce or handle 1,3-butadiene may have several uses for the chemical on-site. Despite this, for the purposes of this assessment each site can only be assigned one OES. The OES was chosen based on the process described in Appendix F, and (if there was not a clear answer) based on professional judgement of what seemed the most prominent activity according to TRI and NEI reporting and the information on the company website. Because deciding the “most prominent activity” is subjective, EPA developed a systematic approach to sorting the release sites in TRI (which was then adapted to NEI). Aside from a CDR indication that a site is a manufacturer, other factors that contributed to the decision of sorting a site into the Manufacturing OES included if the production of a butadiene feedstock was indicated on the company website, or if the facility indicated in TRI that it participated in both producing and in the sale and distribution of 1,3-butadiene.

In three cases companies that reported manufacturing to CDR were assigned a different OES depending on the indicated activities on the site. The Goodyear Tire & Rubber Company in Akron Ohio, Firestone Polymers LLC/Lion Elastomers Orange LLC in Orange, Texas, and Lion Elastomers LLC in Port Neches, Texas, were all reported to CDR 2020 as manufacturers but were mapped to Plastic and rubber

compounding instead of manufacturing. One site from CDR, Invista S.A.R.L. in Wichita, Kansas, did not report releases to TRI or NEI.

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to manufacturing that reported to CDR, TRI, and/or NEI.

EPA did not identify data on facility operating schedules; therefore, because 1,3-butadiene is a large-PV commodity chemical, the Agency assumes 350 days/yr of operation (Section 2.3.2).

3.1.3 Release Assessment

3.1.3.1 Environmental Release Points

Potential releases to air, wastewater, and land include equipment cleaning, transport container cleaning and sampling waste. Additionally, EPA expects stack air releases from vented losses to air during process operations, and fugitive air releases from leakage of pipes, flanges, and accessories used for transport. Fugitive emissions may also occur at loading racks and container filling from equipment leaks, sampling, and displaced vapor as containers are filled.

3.1.3.2 Environmental Release Assessment Results

EPA used 2016-2021 TRI, 2017 NEI, and 2020 NEI data to estimate environmental releases during the manufacture of 1,3-butadiene, as presented in Table 3-1. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, indirectly through the transfer to a non-POTW WWT facility, fugitive air, stack air, and land disposal.

Table 3-1. Summary of Environmental Releases During the Manufacture of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	2.3	371	350	6.5E−03	1.1	4	TRI
WWT	7,500	2.1E04		21.5	59	3	TRI
Fugitive air	360	8,419		1.0	24	37	TRI
Fugitive air	649	7,139		1.9	20	45	NEI
Stack air	1,142	3.3E04		3.3	95	39	TRI
Stack air	665	1.7E04		2.0	46	45	NEI
Land	0.45	120		1.3E−03	0.34	9	TRI

3.1.4 Occupational Exposure Assessment

3.1.4.1 Worker Activities

During manufacture, workers are potentially exposed to 1,3-butadiene via inhalation of vapors during equipment cleaning, container cleaning, and packaging and loading of 1,3-butadiene into transport containers for shipment. EPA identified examples of engineering controls (*e.g.*, process flow leak prevention technology) used at some 1,3-butadiene manufacturing sites during product sampling, laboratory analysis, and product loading; however, EPA did not identify the extent to which these engineering controls are used at all sites that manufacture 1,3-butadiene (Krishnan et al., 1987). EPA did not identify information on worker personal protective equipment (PPE) used at 1,3-butadiene

manufacturing sites.

ONUs include employees (*e.g.*, supervisors, managers) that work at the manufacturing facility, but do not directly handle 1,3-butadiene. Generally, EPA expects ONUs to have lower inhalation exposures than workers who handle the chemicals directly.

3.1.4.2 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 1,3-butadiene during manufacturing (U.S. BLS, 2023). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant Standard Occupational Classification (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 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

Table 3-2 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.1.2.

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

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
63	325199 – All Other Basic Organic Chemical Manufacturing	39	5

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

3.1.4.3 Occupational Inhalation Exposure Results

For manufacturing of 1,3-butadiene, EPA was provided inhalation monitoring data by ACC. The ACC report includes 5,676 full-shift PBZ samples for workers and ONUs collected from 2010 to 2019 (ToxStrategies, 2021). The report includes a compilation and analyses of existing air concentrations of 1,3-butadiene from 47 consortium member facilities.

The report includes air concentration samples with the following worker descriptions:

- Infrastructure/Distribution Operations;
- Instrument and Electrical;
- Laboratory Technician;
- Machinery and Specialists Group;
- Maintenance;
- Operations Onsite;
- Safety Health and Engineering; and,
- ONU.

The report includes samples taken during routine operations, as well as those collected during nonroutine and turnaround operations. Nonroutine operations encompass process upsets and unplanned

maintenance, while turnaround operations refer to planned maintenance shutdowns of process units. Both types of conditions are infrequent.

The ACC dataset did not differentiate between manufacturing and processing samples, so EPA used all the ACC data for this OES. The full-shift samples, ranging from 8 to 12 hours, covered tasks such as maintenance, sample collection, and process condition monitoring. The dataset presented 50th and 95th percentile TWAs for each worker description (ToxStrategies, 2021).

While the EPA identified other data sources containing inhalation monitoring data for workers involved in the manufacturing of 1,3-butadiene, the ACC data was ultimately used due to its higher data quality and recency. The ACC dataset focuses on U.S. sites and includes comprehensive metadata (*e.g.*, sample times, worker descriptions), while the other identified data were often from other countries, were dated (some collected before the OSHA PEL was established), and/or lacked critical metadata needed for an occupational exposure assessment.

EPA compiled the 50th and 95th percentile 8- and 12-hour TWA concentrations from ACC to represent a central tendency and high-end estimate of potential occupational inhalation exposures, respectively, for this scenario. Using these 8- and 12-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 3-3 and Table 3-4. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-3. 8-Hour Duration of Inhalation Exposures to 1,3-Butadiene During Manufacturing, Based on ACC 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)	
		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)	Central Tendency (ppm)
Infrastructure/ distribution operations	455[a]	0.45	2.5E−02	0.31	1.7E−02	0.22	1.3E−02	0.22	1.2E−02	5.5E−02	2.4E−03
Instrument and electrical	313[b]	0.16	2.0E−02	0.11	1.4E−02	8.0E−02	1.0E−02	7.8E−02	9.7E−03	2.0E−02	1.9E−03
Laboratory technician	215[c]	0.24	2.5E−02	0.16	1.7E−02	0.12	1.3E−02	0.11	1.2E−02	2.9E−02	2.4E−03
Machinery and specialists' group	222[d]	0.28	6.0E−03	0.19	4.1E−03	0.14	3.0E−03	0.13	2.9E−03	3.4E−02	5.7E−04
Maintenance technician	354[e]	0.23	0.15	0.16	0.10	0.12	7.6E−02	0.11	7.4E−02	2.9E−02	1.4E−02
Operations onsite	1952[f]	0.2	2.0E−02	0.14	1.4E−02	0.10	1.0E−02	0.10	9.7E−03	2.4E−02	1.9E−03
Safety, health, and engineering	21[g]	0.36	3.8E−02	0.25	2.6E−02	0.18	1.9E−02	0.18	1.8E−02	4.4E−02	3.6E−03
ONU	39[h]	1.7E−02	8.0E−03	1.2E−02	5.4E−03	8.5E−03	4.0E−03	8.2E−03	3.9E−03	2.1E−03	7.5E−04

Limit of Detection (LOD) Breakdown
a – 353 samples (78%) were below LOD (6.0E−03 to 0.7 ppm)
b – 284 samples (91%) were below LOD (8.0E−03 to 0.35 ppm)
c – 158 samples (73%) were below LOD (6.4E−03 to 0.45 ppm)
d – 178 samples (80%) were below LOD (8.0E−03 to 0.22 ppm)
e – 245 samples (69%) were below LOD (8.0E−04 to 0.38 ppm)
f – 1723 samples (88%) were below LOD (4.0E−03 to 0.45 ppm)
g – 15 samples (71%) were below LOD (0.04 to 0.06 ppm)
h – 30 samples (77%) were below LOD (8.0E−03 to 0.02 ppm)

1629 **Table 3-4. 12-Hour Duration of Inhalation Exposures to 1,3-Butadiene Manufacturing**

Worker Description	Number of Samples	12-Hour TWA Exposure Concentrations		Acute Exposure Concentrations (AC)		Intermediate Average Daily Concentration ($ADC_{intermediate}$)		Average Daily Concentration (ADC)		Lifetime Average Daily Concentration (LADC)	
		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)	Central Tendency (ppm)
Infrastructure/ distribution operations	455[a]	0.45	2.5E−02	0.46	2.6E−02	0.34	1.9E−02	0.21	1.2E−02	5.3E−02	2.3E−03
Instrument and electrical	313[b]	0.16	2.0E−02	0.16	2.0E−02	0.12	1.5E−02	7.5E−02	9.3E−03	1.9E−02	1.8E−03
Laboratory technician	215[c]	0.24	2.5E−02	0.24	2.6E−02	0.18	1.9E−02	0.11	1.2E−02	2.8E−02	2.3E−03
Machinery and specialists' group	222[d]	0.28	6.0E−03	0.28	6.1E−03	0.21	4.5E−03	0.13	2.8E−03	3.3E−02	5.5E−04
Maintenance technician	354[e]	0.23	0.15	0.24	0.16	0.18	0.11	0.11	7.1E−02	2.8E−02	1.4E−02
Operations onsite	1952[f]	0.20	2.0E−02	0.20	2.0E−02	0.15	1.5E−02	9.3E−02	9.3E−03	2.4E−02	1.8E−03
Safety, health, and engineering	21[g]	0.36	3.8E−02	0.37	3.9E−02	0.27	2.8E−02	0.17	1.8E−02	4.3E−02	3.5E−03
ONU	39[h]	1.7E−02	8.0E−03	1.7E−02	8.2E−03	1.3E−02	6.0E−03	7.9E−03	3.7E−03	2.0E−03	7.3E−04

Limit of Detection (LOD) Breakdown
a – 353 samples (78%) were below LOD (6.0E−03 to 0.7 ppm)
b – 284 samples (91%) were below LOD (8.0E−03 to 0.35 ppm)
c – 158 samples (73%) were below LOD (6.4E−03 to 0.45 ppm)
d – 178 samples (80%) were below LOD (8.0E−03 to 0.22 ppm)
e – 245 samples (69%) were below LOD (8.0E−04 to 0.38 ppm)
f – 1723 samples (88%) were below LOD (4.0E−03 to 0.45 ppm)
g – 15 samples (71%) were below LOD (0.04 to 0.06 ppm)
h – 30 samples (77%) were below LOD (8.0E−03 to 0.02 ppm)

1630

3.2 Repackaging

3.2.1 Process Description

Repackaging is listed as a condition of use in final scope for 1,3-butadiene (U.S. EPA, 2020c). EPA expects that 1,3-butadiene and 1,3-butadiene-containing products may be distributed throughout commerce from import sites, or from manufacturing to processing repackaging sites. Import and repackaging sites are expected to distribute 1,3-butadiene to various downstream uses. According to (EPA-HQ-OPPT-2018-0451-0021), liquefied butadiene is shipped by pipelines, ships, barges, rail tank cars, tank trucks and bulk liquid containers. 1,3-butadiene is transported in pressurized containers of various sizes and is required to be inhibited (current industry-wide recognized inhibitor is tertiary butyl catechol or TBC). Also, to minimize the formation of peroxides in 1,3-butadiene during shipping and handling, the oxygen level in the vapor space of loaded equipment is not to exceed 1,000 ppm (EPA-HQ-OPPT-2018-0451-0021). Storage of 1,3-butadiene along with other light hydrocarbons are highly specialized. 1,3-Butadiene should be stored in a cool, dry, well-ventilated area in tightly sealed and pressurized containers. Outside, isolated, or detached storage is preferred; inside storage should be in a non-combustible location as 1,3-butadiene is explosive when mixed with air (U.S. EPA, 1996; NIOSH, 1992).

In general, EPA assessed the transport activities resulting in releases and exposures (*e.g.*, loading, unloading) throughout the various life cycle stages and COUs rather than a single distribution and transport scenario. While this process description includes general language about the transport and storage of 1,3-butadiene that may be relevant to transport activities within other OESs as well, the quantifications for this repackaging OES only address releases and exposures that may result at import and repackaging facilities. Data for assessing releases and exposures occurring during transportation of 1,3-butadiene between facilities are generally not available; however, releases from accidental spills that occur during transport are presented in Section 3.7, which discusses distribution in commerce.

1,3-Butadiene may be imported neat or as a component in a formulation. Figure 3-2 below provides typical release and exposure points during the repackaging of 1,3-butadiene.

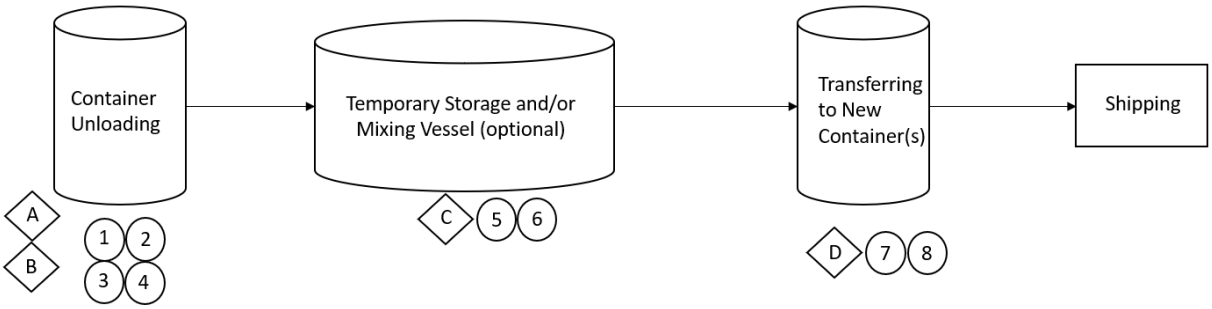


Figure 3-2. Typical Release and Exposure Points During the Repackaging of 1,3-Butadiene
Source: U.S. EPA, 2022

Environmental Releases:

1. Releases to air from unloading volatile chemicals from transport containers.
2. Releases to air, water, incineration, or landfill from unloading solids from transport containers.
3. Releases to water, incineration or land from transport container residue (via container cleaning or direct disposal of empty containers).
4. Releases to air from cleaning transport containers containing volatile chemicals
5. Releases to water, incineration or land from cleaning of storage/mixing vessels and other equipment.
6. Releases to air from cleaning equipment used to process volatile chemicals.
7. Releases to air from loading volatile chemicals into transport containers.
8. Releases to air, water, incineration, or landfill from loading solids into transport containers.

Occupational Exposures:

A. Inhalation exposures to volatile liquids and dust from unloading transport containers.
B. Inhalation exposures to volatile liquids from transport container cleaning.
C. Inhalation exposures to volatile liquids from equipment cleaning.
D. Inhalation exposures to volatile liquids from loading transport containers.

3.2.2 Facility Estimates

In the 2020 CDR, seven companies chose to report process volumes. They reported importing between 5 and 200 million lb each of neat 1,3-butadiene that was at least 90 percent purity by weight (U.S. EPA, 2020b). Using CDR, TRI, and NEI, EPA identified 115 facilities that potentially repackaged 1,3-butadiene.

Facilities that produce or handle 1,3-butadiene may have several uses for the chemical on-site. Despite this, for the purposes of EPA's assessment, each site can only be assigned one OES. The OES was selected using professional judgment to reflect the most prominent activity according to TRI and NEI reporting and the information on the company website. Because deciding the "most prominent activity" is subjective, EPA developed a systematic approach to sorting these release sites in TRI (which was then adapted to NEI). A site was sorted into the repackaging OES if it reported to one of the following three NAICS codes: 424690, (Other Chemical and Allied Products Merchant Wholesalers), 424710 (Petroleum Bulk Stations and Terminals), and 486910 (Pipeline Transportation of Refined Petroleum Products). For other repackaging facilities, factors that may have contributed to the decision include if the name of the facility included "Tank farm" or "Terminal" or if the company information indicated that the facility was primarily a repackaging facility.

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to repackaging that reported to CDR, TRI, and/or NEI.

EPA did not identify data on facility operating schedules; therefore, the Agency assumes that repackaging occurs 7 days/week and 50 weeks/yr (with 2 weeks down for turnaround), which results in an estimate of 350 days/yr of operation (Section 2.3.2).

3.2.3 Release Assessment

3.2.3.1 Environmental Release Points

Potential releases to air, water, or land may occur from loading and unloading of 1,3-butadiene from transport containers, cleaning transport containers, cleaning of storage or mixing vessels and other equipment, cleaning equipment used to process the chemical, and loading into transport containers.

3.2.3.2 Environmental Release Assessment Results

EPA used 2016 to 2021 TRI, 2017 NEI, and 2020 NEI data to estimate environmental releases during the repackaging of 1,3-butadiene, as presented in Table 3-5. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, fugitive air, stack air, and land disposal.

Table 3-5. Summary of Environmental Releases During the Repackaging of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	2.3	4.3	350	6.5E−0	1.2E−02	1	TRI
Fugitive air	18	3,559		5.1E−02	10	22	TRI
Fugitive air	1.6	999		4.6E−03	2.8	89	NEI
Stack air	21	1,970		5.9E−02	5.6	24	TRI
Stack air	23	1,127		7.4E−02	3.2	89	NEI
Land	2.3	6.8		6.5E−0	1.9E−02	2	TRI

3.2.4 Occupational Exposure Assessment

3.2.4.1 Worker Activities

During repackaging, worker exposures via inhalation of 1,3-butadiene vapors may occur when transferring 1,3-butadiene from the import vessels (*e.g.*, chemical tankers, rail cars, intermodal tank containers) into smaller containers, cleaning import vessels, sampling, and cleaning equipment. EPA did not find any information on the extent to which engineering controls and worker PPE are used at facilities that repackage 1,3-butadiene into smaller containers.

ONUs include employees (*e.g.*, supervisors, managers) that work at the import site where repackaging occurs but do not directly handle 1,3-butadiene. Therefore, EPA expects the ONUs to have lower inhalation exposures than workers who handle the chemicals directly.

3.2.4.2 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 1,3-butadiene during repackaging (U.S. BLS, 2023). 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 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
- 424720 – Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals)
- 486910 – Pipeline Transportation of Refined Petroleum Products

Table 3-6 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.2.2.

Table 3-6. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Repackaging

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
115	424610 – Plastics Materials and Basic Forms and Shapes Merchant Wholesalers	4	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)		
	486910 – Pipeline Transportation of Refined Petroleum Products		

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

3.2.4.3 Occupational Inhalation Exposure Results

EPA did not identify monitoring data for the Repackaging OES; however, EPA expects the exposures to be similar to unloading/loading worker activities during the Manufacturing OES. Therefore, EPA used the manufacturing monitoring data as "analogous data" for repackaging. EPA refers to analogous monitoring data as monitoring data for the same chemical, for a similar OES.

For loading and unloading of 1,3-butadiene, EPA identified 158 task-based worker PBZ samples from the ACC industrial hygiene report (ToxStrategies, 2021). The worker samples collected include loading and unloading of product which involves opening of storage vessels, hose connections to truck tankers, rail cars or cargo vessels and pumping of pressurized liquid 1,3-butadiene. The sample durations ranged from 15 to 239 minutes. EPA assumes that at a repackaging facility, the bulk of the day will be spent repackaging such that the task-based samples are representative of a full-shift exposure. The Agency did not identify any full-shift ONU PBZ samples during data evaluation. Therefore, EPA used the central tendency from workers to represent ONU exposures.

EPA compiled the 50th and 95th percentile 8-hour TWA concentrations from the ACC data (ToxStrategies, 2021) 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 3-7. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-7. Inhalation Exposures of Workers to 1,3-Butadiene During Repackaging, Based on ACC Data

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Number of Samples	158		0	
8-hour TWA Exposure Concentrations	15	1.1	1.1	1.1
Acute Exposure Concentrations (AC)	10	0.75	0.75	0.75
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	7.5	0.55	0.55	0.55
Average Daily Concentration (ADC)	7.3	0.53	0.53	0.53
Lifetime Average Daily Concentration (LADC)	1.8	0.10	0.13	0.10

3.3 Processing as a Reactant

3.3.1 Process Description

The final scope for 1,3-butadiene lists processing as a reactant as an in-scope condition of use (U.S. EPA, 2020c). Processing as a reactant or intermediate is the use of 1,3-butadiene as a feedstock in the production of another chemical via a chemical reaction in which 1,3-butadiene is consumed to form the product. When used as a reactant, 1,3-butadiene is received in liquid form in pressurized containers by tank truck or railcar. EPA assumes that 1,3-butadiene is used as reagent grade, 99.5 percent or higher purity from the manufacturing process (Sun and Wristers, 2002).

ACC provided comments on ways 1,3-butadiene is used as a chemical intermediate (EPA-HQ-OPPT-2018-0451-0021). One use is in the production of nylon. In this process, 1,3-butadiene is subjected to direct hydrocyanation to form pentenitrile compounds and adiponitrile, which are further hydrocyanated to form hexamethylenediamine. This compound is polymerized to manufacture nylon resins. Another process in which 1,3-butadiene is used as a chemical intermediate is in the production of neoprene rubber, which involves 1,3-butadiene being chlorinated to form chloroprene and then polymerized to form neoprene. 1,3-Butadiene is also used to produce 1,4-hexadiene (used to create ethylene-propylene terpolymer), sulfolane (an extraction solvent), and 1,5,9-cyclodecatriene (used in the production of nylon fibers and resins). Based on inter/intra-agency comments, 1,3-butadiene is also processed as a reactant in propellant manufacturing by the United States Department of Defense (DOD).

Figure 3-3, provided by the ACC, illustrates an example adiponitrile production process. Adiponitrile is then used to form hexamethylenediamine and finally nylon resins. As the diagram indicates, 1,3-butadiene is reacted to near completion (EPA-HQ-OPPT-2018-0451-0041).

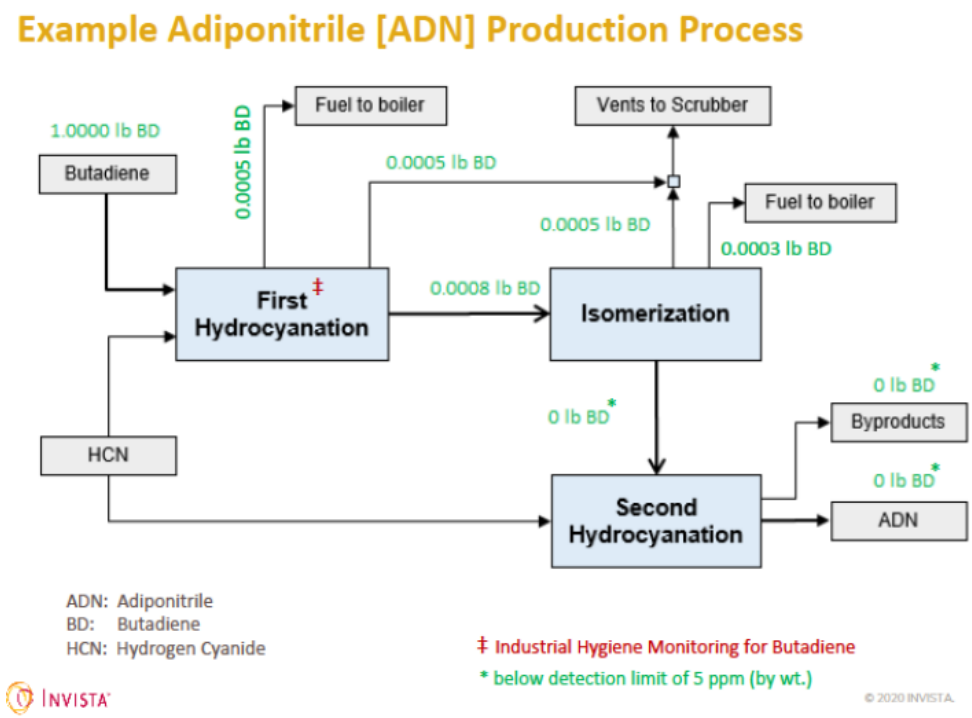


Figure 3-3. Illustration of an Adiponitrile Production Process
Source: ACC/Invista.

3.3.2 Facility Estimates

Between 2016 and 2021, EPA used TRI, NEI, and CDR to identify 103 facilities that potentially process 1,3-butadiene as a reactant. In 1993, the domestic production capacity for adiponitrile was 712,000 tons/yr (U.S. EPA, 1996). It was reported by ACC in 2018 that roughly 26 to 32 percent of 1,3-butadiene PV goes toward the production of intermediate chemicals such as adiponitrile and chloroprene (EPA-HQ-OPPT-2018-0451-0021). Taking the high estimate of PV from CDR (5 billion lb), it can be estimated that up to 1.6 billion lb of 1,3-butadiene goes toward an activity covered by this OES. EPA did not identify production capacities for the production of nylon resins, neoprene rubber, or propellants.

Facilities that produce or handle 1,3-butadiene may have several uses for the chemical on-site. Despite this, for the purposes of our assessment each site can only be assigned one OES. The OES was chosen based generally on what seemed the most prominent activity according to TRI and NEI reporting and the information on the company website. Since deciding the "most prominent activity" is subjective, EPA developed a systematic approach to sorting these release sites in TRI (which was then adapted to NEI). Reviewing the company information for each facility was an important step in sorting a site into Processing as a Reactant OES. If the company information indicated the production of a plastic/rubber product in which 1,3-butadiene is known to be in an intermediate stage (such as nylon) or if the product was indicated to be an intermediate product (such as emulsion, liquid, or dispersion), then processing as a reactant was chosen. Within TRI, reported uses that indicated to EPA that processing as a reactant may be the appropriate OES for the facility include the presence of "Use as a Reactant," particularly along with uses/sub-uses such as "Feedstock," "Raw Material," and "Intermediate."

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to processing as a reactant that reported to CDR, TRI, and/or NEI.

EPA did not identify data on facility operating schedules; therefore, since 1,3-butadiene is a commodity

chemical most commonly used to manufacture other chemicals, EPA assumes that the facility operates 7 days/week and 50 weeks/yr (with 2 weeks down for turnaround) and that the facility is producing and releasing the chemical daily during operation. This results in an estimated 350 days/yr of operation (Section 2.3.2).

3.3.3 Release Assessment

3.3.3.1 Environmental Release Points

EPA expects releases to occur during container and equipment cleaning, maintenance, and sampling. Environmental releases may also occur during the unloading of 1,3-butadiene from transport containers into intermediate storage tanks and process vessels. Equipment leaks may occur while connecting and disconnecting hoses and transfer lines. Additionally, EPA expects stack air releases from vented losses to air during process operations, and fugitive air releases from leakage of pipes, flanges, and accessories used for transport.

3.3.3.2 Environmental Release Assessment Results

EPA used 2016 to 2021 TRI, 2017 NEI, and 2020 NEI data to estimate environmental releases during the processing as a reactant of 1,3-butadiene, as presented in Table 3-8. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, indirectly through the transfer to a POTW, indirectly through the transfer to a non-POTW WWT facility, fugitive air, stack air, and land disposal.

Table 3-8. Summary of Environmental Releases During the Processing as a Reactant of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	2.3	21	350	6.5E−03	6.0E−02	4	TRI
POTW	1.2	6.3		3.5E−03	1.8E−02	3	TRI
WWT	0.5	0.5		1.3E−03	1.3E−03	1	TRI
Fugitive air	64	1,778		0.18	5.08	54	TRI
Fugitive air	49	2,986		0.13	8.2	70	NEI
Stack air	94	4,419		0.27	13	53	TRI
Stack air	54	3,632		0.15	10	70	NEI
Land	0.69	207		2.0E−03	0.59	13	TRI

3.3.4 Occupational Exposure Assessment

3.3.4.1 Worker Activities

While processing 1,3-butadiene as a reactant, worker exposures may occur via inhalation of vapors during container unloading and loading, product sampling, transport container cleaning, maintenance operations, and general onsite operations. EPA received comment (EPA-HQ-OPPT-2018-0451-0066) from INVISTA that describes some engineering controls and worker PPE used on their adiponitrile

manufacturing facility, where 1,3-butadiene is processed as a reactant. During routine operations, 1,3-butadiene is pumped from storage into the process area using automated controls, operated from within a control room. The process area is a closed piping reaction system with automated controls and no manual sampling activities occur in this section of the unit. During non-routine activities (such as clearing of equipment containing 1,3-butadiene for maintenance, which may occur around two times per month, or troubleshooting), engineering controls include a venting of all vapors from equipment with a hard-piped connection to a flare system, after which testing occurs to ensure the efficacy of the vent. Workers may then open equipment. PPE worn during the initial opening of the equipment include a chemical suit, gloves, and respirator (EPA-HQ-OPPT-2018-0451-0068).

ONUs include supervisors, managers, and other employees that work in the processing area but do not directly contact 1,3-butadiene received or processed onsite or handle polymerized product. Therefore, EPA expects the ONUs to have lower inhalation exposures than workers who handle the chemicals directly.

3.3.4.2 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 1,3-butadiene during processing as a reactant (U.S. BLS, 2023). 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 includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

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

Table 3-9 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.3.2.

Table 3-9. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Processing as a Reactant

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
103	325110 – Petrochemical Manufacturing	43	8
	325199 – All Other Basic Organic Chemical Manufacturing		
	325211 – Plastics Material and Resin Manufacturing		

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

3.3.4.3 Occupational Inhalation Exposure Results

For processing as a reactant, EPA used the ACC dataset described in Section 3.1.4.3, which includes

5,676 full-shift PBZ samples for workers and ONUs collected from 2010 to 2019 (ToxStrategies, 2021). The dataset included routine, nonroutine, and turnaround operations. The sample durations ranged from 8 to 12 hours. The worker samples collected include maintenance of electrical equipment and process equipment, sample collection, and process condition monitoring. The ACC presented 50th and 95th percentiles per worker description (ToxStrategies, 2021). The entire ACC dataset was applied to the exposure estimates because the EPA cannot distinguish whether the data pertained specifically to manufacturing or processing.

While the EPA identified other data sources containing inhalation monitoring data for workers involved in the processing of 1,3-butadiene as a reactant, the ACC data was ultimately used due to its higher data quality and recency. The ACC dataset focuses on U.S. sites and includes comprehensive metadata (*e.g.*, sample times, worker descriptions), while the other identified data were often from other countries, were dated (with some collected before the OSHA PEL was established), and/or lacked critical metadata needed for an occupational exposure assessment.

EPA compiled the 50th and 95th percentile 8- and 12-hour TWA concentrations from the ACC to represent a central tendency and high-end estimate of potential occupational inhalation exposures, respectively, for this scenario. Using these 8- and 12-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 3-10 and Table 3-11. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-10. 8-Hour Duration of Inhalation Exposures of Workers to 1,3-Butadiene During Processing as a Reactant, Based on ACC 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)	
		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)	Central Tendency (ppm)
Infrastructure/ distribution operations	455[a]	0.45	2.5E−02	0.31	1.7E−02	0.22	1.3E−02	0.22	1.2E−02	5.5E−02	2.4E−03
Instrument and electrical	313[b]	0.16	2.0E−02	0.11	1.4E−02	8.0E−02	1.0E−02	7.8E−02	9.7E−03	2.0E−02	1.9E−03
Laboratory technician	215[c]	0.24	2.5E−02	0.16	1.7E−02	0.12	1.3E−02	0.11	1.2E−02	2.9E−02	2.4E−03
Machinery and specialists' group	222[d]	0.28	6.0E−03	0.19	4.1E−03	0.14	3.0E−03	0.13	2.9E−03	3.4E−02	5.7E−04
Maintenance technician	354[e]	0.23	0.15	0.16	0.10	0.12	7.6E−02	0.11	7.4E−02	2.9E−02	1.4E−02
Operations onsite	1952[f]	0.2	2.0E−02	0.14	1.4E−02	0.10	1.0E−02	0.10	9.7E−03	2.4E−02	1.9E−03
Safety, health, and engineering	21[g]	0.36	3.8E−02	0.25	2.6E−02	0.18	1.9E−02	0.18	1.8E−02	4.4E−02	3.6E−03
ONU	39[h]	1.7E−02	8.0E−03	1.2E−02	5.4E−03	8.5E−03	4.0E−03	8.2E−03	3.9E−03	2.1E−03	7.5E−04

Limit of Detection (LOD) Breakdown
a – 353 samples (78%) were below LOD (6.0E−03 to 0.7 ppm)
b – 284 samples (91%) were below LOD (8.0E−03 to 0.35 ppm)
c – 158 samples (73%) were below LOD (6.4E−03 to 0.45 ppm)
d – 178 samples (80%) were below LOD (8.0E−03 to 0.22 ppm)
e – 245 samples (69%) were below LOD (8.0E−04 to 0.38 ppm)
f – 1723 samples (88%) were below LOD (4.0E−03 to 0.45 ppm)

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)	
		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)	Central Tendency (ppm)
g – 15 samples (71%) were below LOD (0.04 to 0.06 ppm) h – 30 samples (77%) were below LOD (8.0E−03 to 0.02 ppm)											

Table 3-11. 12-Hour Duration of Inhalation Exposures to 1,3-Butadiene During Processing as a Reactant, Based on ACC Data

Worker Description	Number of Samples	12-Hour TWA Exposure Concentrations		Acute Exposure Concentrations (AC)		Intermediate Average Daily Concentration ($ADC_{intermediate}$)		Average Daily Concentration (ADC)		Lifetime Average Daily Concentration (LADC)	
		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)	Central Tendency (ppm)
Infrastructure/ distribution operations	455[a]	0.45	2.5E−02	0.46	2.6E−02	0.34	1.9E−02	0.21	1.2E−02	5.3E−02	2.3E−03
Instrument and electrical	313[b]	0.16	2.0E−02	0.16	2.0E−02	0.12	1.5E−02	7.5E−02	9.3E−03	1.9E−02	1.8E−03
Laboratory technician	215[c]	0.24	2.5E−02	0.24	2.6E−02	0.18	1.9E−02	0.11	1.2E−02	2.8E−02	2.3E−03
Machinery and specialists' group	222[d]	0.28	6.0E−03	0.28	6.1E−03	0.21	4.5E−03	0.13	2.8E−03	3.3E−02	5.5E−04
Maintenance technician	354[e]	0.23	0.15	0.24	0.16	0.18	0.11	0.11	7.1E−02	2.8E−02	1.4E−02
Operations onsite	1952[f]	0.20	2.0E−02	0.20	2.0E−02	0.15	1.5E−02	9.3E−02	9.3E−03	2.4E−02	1.8E−03
Safety, health, and engineering	21[g]	0.36	3.8E−02	0.37	3.9E−02	0.27	2.8E−02	0.17	1.8E−02	4.3E−02	3.5E−03
ONU	39[h]	1.7E−02	8.0E−03	1.7E−02	8.2E−03	1.3E−02	6.0E−03	7.9E−03	3.7E−03	2.0E−03	7.3E−04

Limit of Detection (LOD) Breakdown
a – 353 samples (78%) were below LOD (6.0E−03 to 0.7 ppm)
b – 284 samples (91%) were below LOD (8.0E−03 to 0.35 ppm)
c – 158 samples (73%) were below LOD (6.4E−03 to 0.45 ppm)
d – 178 samples (80%) were below LOD (8.0E−03 to 0.22 ppm)
e – 245 samples (69%) were below LOD (8.0E−04 to 0.38 ppm)
f – 1723 samples (88%) were below LOD (4.0E−03 to 0.45 ppm)
g – 15 samples (71%) were below LOD (0.04 to 0.06 ppm)
h – 30 samples (77%) were below LOD (8.0E−03 to 0.02 ppm)

3.4 Processing – Incorporation into Formulation, Mixture or Reaction Product

3.4.1 Process Description

Incorporation into a formulation, mixture or reaction product refers to the process of mixing or blending of several raw materials to obtain a single product or preparation. In the 2016 CDR, companies reported use of 1,3-butadiene in the manufacture of petrochemicals, as well as in the manufacturing of rubber products (U.S. EPA, 2020b). The final scope for 1,3-butadiene also lists that the chemical is used in adhesive manufacturing, paints and coatings manufacturing, and oil and grease lubricant manufacturing (U.S. EPA, 2020c).

Finished lubricants processing consists of blending base stock lubricants with additive chemicals to create a finished product. The three most common blending methods include batch, partial in-line, and continuous in-line blending (OECD, 2020). 1,3-butadiene is used as a viscosity improver in automotive lubricants, and products made with 1,3-butadiene are typically added in concentrations of 2 to 15 percent. The formulation of paints and coatings typically involves dispersion, milling, finishing and filling into final packages (OECD, 2010). Polybutadiene is specifically used as a cationic binder in paint primers, and is present at concentrations of less than 10 percent.

In adhesive manufacturing, 1,3-butadiene is used as a binder. One company reporting to CDR (U.S. EPA, 2020b) indicated that the chemical is used as an intermediate in the adhesive manufacturing sector. Substances in Preparations in Nordic Countries (SPIN) (2019) also identified use of 1,3-butadiene in adhesives and binding agents in Nordic countries. According to the Aerospace Industries Association (AIA), 1,3-butadiene is used in adhesives critical to electrical and circuit boards for its thermal properties and low outgassing properties (important for space applications). They also note that it is a component of epoxy resin adhesive systems for bonding and sealing of glass to metal components (EPA-HQ-OPPT-2018-0451-0009). 1,3-Butadiene-specific formulation processes were not identified for the manufacture of adhesives; however, ESDs published by the OECD have been identified that provide general process descriptions for these types of products. Adhesive formulation involves mixing together volatile and non-volatile chemical components in sealed, unsealed or heated processes (OECD, 2009a). Sealed processes are most common for adhesive formulation because many adhesives are designed to set or react when exposed to ambient conditions (OECD, 2009a). Figure 3-4 below provides typical release and exposure points during the incorporation of 1,3-butadiene into adhesives.

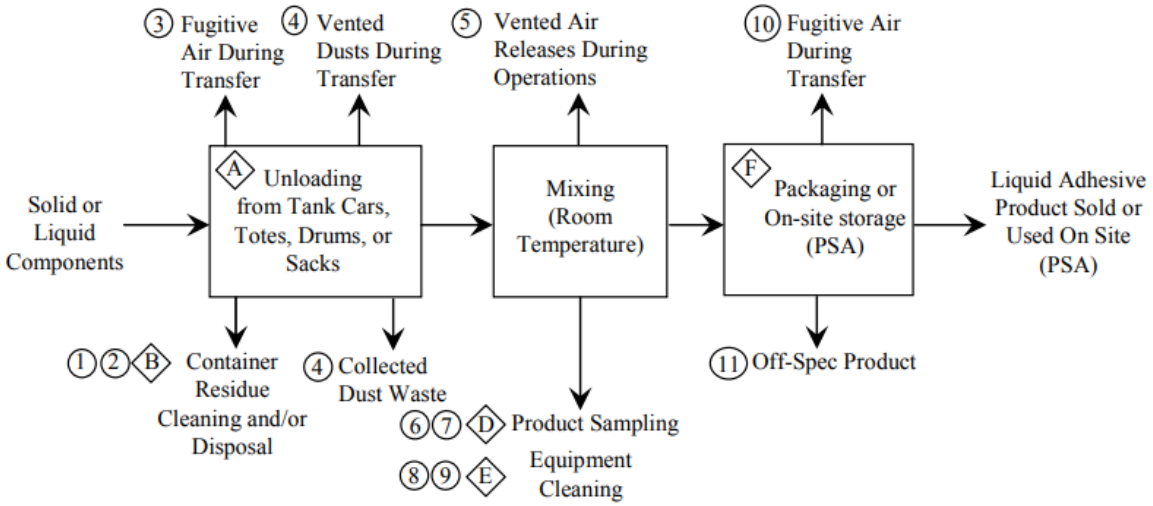


Figure 3-4. Typical Release and Exposure Points During Adhesive and Sealant Formulation
Source: OECD, 2009a

Environmental Releases:

1. Container residue from adhesive component transport container released to water, incineration, or landfill.
2. Open surface losses of volatile chemicals to air during container cleaning
3. Transfer operation losses to air of volatile chemicals from unloading the adhesive component.
4. Dust losses vented to outside air from the transfer of a solid/powdered adhesive component into the process. Alternatively, these dusts are captured on vent filters or settle within the workspace, and are subsequently collected and released to water, incineration, or landfill.
5. Vented losses of volatile chemicals to air during mixing operations.
6. Product sampling wastes disposed to water, incineration or landfill (not quantified in this ESD).
7. Open surface losses of volatile chemicals during product sampling.
8. Equipment cleaning releases to water, incineration, or landfill.
9. Open surface losses of volatile chemicals to air during equipment cleaning.
10. Transfer operation losses of volatile chemicals to air from loading adhesive product into transport containers.
11. Off-spec adhesive product released to water, incineration, or landfill.

Occupational Exposures:

A. Inhalation exposure from unloading solid or liquid adhesive components.
B. Inhalation exposure to solid or liquid adhesive components during container cleaning.
C. Inhalation exposure to liquid adhesive product during sampling activities.
D. Inhalation exposure to liquid during equipment cleaning of mixing and other process equipment.
E. Inhalation exposure to liquids during the packaging of adhesive formulations into containers.

1,3-Butadiene is also listed as a processing aid in petrochemical manufacture, but EPA found no butadiene-specific formulation processes or resources on this use. In the 2016 CDR, one company reported a 2014 PV of 2,751,366 lb of 1,3-butadiene used in the production of petrochemical processing aids (U.S. EPA, 2016). SPIN also identified use of 1,3-butadiene in aerosol propellants in Nordic countries up to year 2016, and the American Coatings Association noted in a public comment that "Manufacturers note residual amounts of the chemical in aerosol propellants" (EPA-HQ-OPPT-2018-0451-0005). Plastic and rubber production are covered in Sections 3.5 and 3.6.

3.4.2 Facility Estimates

Using TRI and NEI, EPA identified 178 facilities that potentially process 1,3-butadiene by incorporation into formulation, mixture or reaction product. Due to CBI claims on the annual PV of 1,3-butadiene, EPA does not present annual or daily site throughputs for adhesive manufacturing, paints and coatings manufacturing, and oil and grease lubricant manufacturing. The ESD on Adhesive Formulation estimates the number of operating days based on PV information and an annual adhesive production rate of 1.6 to 17 million kg/site-yr (OECD, 2009a). The ESD on Chemical Additives in Automotive

Lubricants estimates 256 operating days/yr for formulation and an annual processing rate of 19 million kg lubricant/site-yr (OECD, 2020).

Facilities that produce or handle 1,3-butadiene may have several uses for the chemical on-site. Despite this, for the purposes of our assessment each site can only be assigned one OES. The OES was chosen using professional judgment to reflect the most prominent activity according to TRI and NEI reporting and the information on the company website. Since deciding the "most prominent activity" is subjective, EPA developed a systematic approach to sorting these release sites in TRI (which was then adapted to NEI). If a facility has the NAICS code of 325520 (Adhesive Manufacturing), the OES of Processing - Incorporation into formulation, mixture, or reaction product is assigned to the facility. Otherwise, within TRI, if a facility indicates that they produce 1,3-butadiene as a byproduct or manufactured impurity, and no specific on-site use for the chemical is indicated, the OES of Processing - incorporation into formulation, mixture, or reaction product may be chosen.

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to incorporation into formulation, mixture, or reaction product that reported to CDR, TRI, and/or NEI.

The ESD on Formulation of Radiation Curable Coatings, Inks and Adhesives estimates 250 operating days/yr (or calculation based on PV information) and an annual production rate of 130,000 kg formulation/site-yr (OECD, 2010).

3.4.3 Release Assessment

3.4.3.1 Environmental Release Points

EPA expects releases to occur to water, incineration, or landfill due to container residue in transport containers, product sample wastes, and equipment cleaning. Due to the chemical's volatility EPA also expects losses to air during container and equipment cleaning, transfer operations such as loading and unloading, product sampling, and mixing operations. EPA also expects stack air releases from vented losses during process operations and packaging into transport containers.

3.4.3.2 Environmental Release Assessment Results

EPA used 2016-2021 TRI, 2017 NEI, and 2020 NEI to estimate environmental releases during the Processing – incorporation into formulation, mixture or reaction product of 1,3-butadiene, as presented in Table 3-12. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, indirectly through the transfer to a POTW, fugitive air, stack air, and land disposal.

Table 3-12. Summary of Environmental Releases During the Incorporation into Formulation, Mixture or Reaction Product of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	7.7	8.8	250	3.1E−02	3.5E−02	2	TRI
POTW	1.4	2.5		5.4E−03	1.0E−02	2	TRI
WWT	79	120		0.32	0.48	1	TRI
Fugitive air	10	712		4.0E−02	2.8	47	TRI
Fugitive air	3.9	282		1.5E−02	0.89	153	NEI
Stack air	56	1,349		0.22	5.4	49	TRI
Stack air	12	455		3.7E−02	1.2	153	NEI
Land	27	1.0E04		0.11	40	4	TRI

3.4.4 Occupational Exposure Assessment

3.4.4.1 Worker Activities

During the formulation of products containing 1,3-butadiene, worker exposures via inhalation of vapors may occur when transferring 1,3-butadiene from transport containers into process vessels, cleaning transport containers, product sampling, equipment cleaning, and packaging formulated products into containers (OECD, 2009a) (U.S. EPA, 2014). EPA did not identify information on engineering controls or worker PPE used at 1,3-butadiene-containing product formulation facilities.

For this OES, ONUs may include supervisors, managers, and other employees that work in the formulation area but do not directly contact 1,3-butadiene that is received or processed onsite or handle the formulated product. Therefore, EPA expects the ONUs to have lower inhalation exposures than workers who handle 1,3-butadiene or the formulations directly.

3.4.4.2 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 1,3-butadiene during incorporation into formulation, mixture or reaction product (U.S. BLS, 2023). 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 includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 325510 – Paint and Coating Manufacturing
- 325520 – Adhesive Manufacturing
- 424690 – Other Chemical and Allied Products Merchant Wholesalers

Table 3-13 summarizes the per site estimates for this OES based on the methodology described,

including the number of sites identified in Section 3.4.2.

Table 3-13. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Incorporation into Formulation, Mixture or Reaction Product

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
178	325510 – Paint and Coating Manufacturing	11	3
	325520 – Adhesive Manufacturing		
	424690 – Other Chemical and Allied Products Merchant Wholesalers		

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

3.4.4.3 Occupational Inhalation Exposure Results

For Processing – incorporation into formulation, mixture, or reaction product, EPA used the ACC dataset described in Section 3.1.4.3 (ToxStrategies, 2021). The dataset includes 5,676 full-shift PBZ samples for workers and ONUs collected from 2010 to 2019 (ToxStrategies, 2021). The dataset included routine, nonroutine, and turnaround operations. The sample durations ranged from 8 to 12 hours. The worker samples collected include maintenance of electrical equipment and process equipment, sample collection, and process condition monitoring. The ACC presented 50th and 95th percentiles per worker description (ToxStrategies, 2021). The entire ACC dataset was applied to the exposure estimates because the EPA cannot distinguish whether the data pertained specifically to manufacturing or processing.

While the EPA identified other data sources containing inhalation monitoring data for workers involved in the incorporation of 1,3-butadiene into formulation, the ACC data was ultimately used due to its higher data quality and recency. This dataset focuses on U.S. sites and includes comprehensive metadata (*e.g.*, sample times, worker descriptions).

EPA compiled 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- and 12-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 3-14 and Table 3-15. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-14. 8-Hour Duration of Inhalation Exposures of Workers to 1,3-Butadiene During Incorporation into Formulation, Mixture or Reaction Product, Based on ACC 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)	
		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)	Central Tendency (ppm)
Infrastructure/ distribution operations	455[a]	0.45	2.5E−02	0.31	1.7E−02	0.22	1.3E−02	0.22	1.2E−02	5.5E−02	2.4E−03
Instrument and electrical	313[b]	0.16	2.0E−02	0.11	1.4E−02	8.0E−02	1.0E−02	7.8E−02	9.7E−03	2.0E−02	1.9E−03
Laboratory technician	215[c]	0.24	2.5E−02	0.16	1.7E−02	0.12	1.3E−02	0.11	1.2E−02	2.9E−02	2.4E−03
Machinery and specialists' group	222[d]	0.28	6.0E−03	0.19	4.1E−03	0.14	3.0E−03	0.13	2.9E−03	3.4E−02	5.7E−04
Maintenance technician	354[e]	0.23	0.15	0.16	0.10	0.12	7.6E−02	0.11	7.4E−02	2.9E−02	1.4E−02
Operations onsite	1952[f]	0.2	2.0E−02	0.14	1.4E−02	0.10	1.0E−02	0.10	9.7E−03	2.4E−02	1.9E−03
Safety, health, and engineering	21[g]	0.36	3.8E−02	0.25	2.6E−02	0.18	1.9E−02	0.18	1.8E−02	4.4E−02	3.6E−03
ONU	39[h]	1.7E−02	8.0E−03	1.2E−02	5.4E−03	8.5E−03	4.0E−03	8.2E−03	3.9E−03	2.1E−03	7.5E−04

Limit of Detection (LOD) Breakdown
a – 353 samples (78%) were below LOD (6.0E−03 to 0.7 ppm)
b – 284 samples (91%) were below LOD (8.0E−03 to 0.35 ppm)
c – 158 samples (73%) were below LOD (6.4E−03 to 0.45 ppm)
d – 178 samples (80%) were below LOD (8.0E−03 to 0.22 ppm)
e – 245 samples (69%) were below LOD (8.0E−04 to 0.38 ppm)
f – 1723 samples (88%) were below LOD (4.0E−03 to 0.45 ppm)
g – 15 samples (71%) were below LOD (0.04 to 0.06 ppm)
h – 30 samples (77%) were below LOD (8.0E−03 to 0.02 ppm)

Table 3-15. 12-Hour Duration of Inhalation Exposures of Workers to 1,3-Butadiene During Incorporation into Formulation, Mixture or Reaction Product, Based on ACC Data

Worker Description	Number of Samples	12-Hour TWA Exposure Concentrations		Acute Exposure Concentrations (AC)		Intermediate Average Daily Concentration ($ADC_{intermediate}$)		Average Daily Concentration (ADC)		Lifetime Average Daily Concentration (LADC)	
		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)	Central Tendency (ppm)
Infrastructure/ distribution operations	455[a]	0.45	2.5E−02	0.46	2.6E−02	0.34	1.9E−02	0.21	1.2E−02	5.3E−02	2.3E−03
Instrument and electrical	313[b]	0.16	2.0E−02	0.16	2.0E−02	0.12	1.5E−02	7.5E−02	9.3E−03	1.9E−02	1.8E−03
Laboratory technician	215[c]	0.24	2.5E−02	0.24	2.6E−02	0.18	1.9E−02	0.11	1.2E−02	2.8E−02	2.3E−03
Machinery and specialists' group	222[d]	0.28	6.0E−03	0.28	6.1E−03	0.21	4.5E−03	0.13	2.8E−03	3.3E−02	5.5E−04
Maintenance technician	354[e]	0.23	0.15	0.24	0.16	0.18	0.11	0.11	7.1E−02	2.8E−02	1.4E−02
Operations onsite	1952[f]	0.20	2.0E−02	0.20	2.0E−02	0.15	1.5E−02	9.3E−02	9.3E−03	2.4E−02	1.8E−03
Safety, health, and engineering	21[g]	0.36	3.8E−02	0.37	3.9E−02	0.27	2.8E−02	0.17	1.8E−02	4.3E−02	3.5E−03
ONU	39[h]	1.7E−02	8.0E−03	1.7E−02	8.2E−03	1.3E−02	6.0E−03	7.9E−03	3.7E−03	2.0E−03	7.3E−04

Limit of Detection (LOD) Breakdown
a – 353 samples (78%) were below LOD (6.0E−03 to 0.7 ppm)
b – 284 samples (91%) were below LOD (8.0E−03 to 0.35 ppm)
c – 158 samples (73%) were below LOD (6.4E−03 to 0.45 ppm)
d – 178 samples (80%) were below LOD (8.0E−03 to 0.22 ppm)
e – 245 samples (69%) were below LOD (8.0E−04 to 0.38 ppm)
f – 1723 samples (88%) were below LOD (4.0E−03 to 0.45 ppm)

Worker Description	Number of Samples	12-Hour TWA Exposure Concentrations		Acute Exposure Concentrations (AC)		Intermediate Average Daily Concentration ($ADC_{intermediate}$)		Average Daily Concentration (ADC)		Lifetime Average Daily Concentration (LADC)	
		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)	Central Tendency (ppm)
g – 15 samples (71%) were below LOD (0.04 to 0.06 ppm) h – 30 samples (77%) were below LOD (8.0E−03 to 0.02 ppm)											

2084

3.5 Plastics and Rubber Compounding

3.5.1 Process Description

Rubber and plastics product manufacturing was listed as an in-scope COU in the final scope for 1,3-butadiene (U.S. EPA, 2020c). 1,3-Butadiene is most commonly used as a monomer in polymerization processes, often to produce rubbers and plastics such as styrene-butadiene, polybutadiene, acrylonitrile-butadiene-styrene, and nitrile rubber (Sun and Wristers, 2002). Here, dry solvent, initiator, other monomers, and 1,3-butadiene are loaded into a reactor until all monomers are depleted. Then, the chain ends are terminated, and the resulting polymer solution is pumped to a blend tank. These processes can be run in batch or continuous operation (EPA-HQ-OPPT-2018-0451-0022).

Compounding involves the blending into the polymers of various types of additives, including fillers, reinforcements, and colors to meet the requirements of specific applications for plastic materials (OECD, 2009b). These polymers, such as acrylonitrile butadiene styrene (ABS), polybutadiene, and styrene-butadiene, are manufactured using 1,3-butadiene, and are often involved in compounding processes to produce final plastic and rubber products. Copolymers of styrene and butadiene containing over 45 percent 1,3-butadiene possess rubber like properties, while copolymers containing over 45 percent styrene have plastic or latex-like qualities (U.S. EPA, 1996). Unreacted 1,3-butadiene monomer is recovered and recycled during the process and according to a comment submitted by the International Institute of Synthetic Rubber Producers, Inc., synthetic rubber such as butadiene rubber (BR) and solution styrene butadiene rubber (SSBR) polymers contain less than 50 ppb of residual 1,3-butadiene monomer (EPA-HQ-OPPT-2018-0451-0027).

ABS polymers can be compounded using batch and continuous melt mixers, and both single- and twin-screw extruders. The selected machine depends on the additives that are being mixed with the polymer, and whether the mixture requires dispersive mixing, distributive mixing, or both. ABS plastics and rubbers can be made in the compounding process by combining emulsion polymers having a high rubber content with mass- or suspension-polymerized styrene-acrylonitrile resin (Sun and Wristers, 2002).

For other types of 1,3-butadiene-containing plastics and rubbers, the ESD on Plastic Additives (OECD, 2009b) published by the OECD and the Draft Generic Scenario for Use of Additives in Plastics Compounding (U.S. EPA, 2021c) currently in development by EPA provide generic process descriptions for the compounding of plastics and rubbers. The GS indicates that during plastics compounding, a polymer resin is blended with additives and other raw materials to form a masterbatch in either open or closed blending processes (U.S. EPA, 2021c). Tumble blenders, ball blenders, gravity mixers, paddle/double arm mixers, intensive vortex action mixers, and Banbury internal mixers are all closed systems and are considered to be blending processes. Two-roll mills and extruders are partially open systems and represent all-in-one processes that perform blending and forming of the final compounded plastic or rubber (*e.g.* pellets or sheets) (U.S. EPA, 2021c; OECD, 2009b). EPA expects compounded plastic or rubber materials to be converted into solid articles as described in Section 3.6.

Figure 3-5, provided by International Institute of Synthetic Rubber Producers (IISRP), illustrates one type of a typical emulsion process, in this case producing emulsion styrene-butadiene rubber (ESBR). In this process conversation may be between 60 to 80 percent, with the 1,3-butadiene being recovered and recycled back into the process. 1,3-Butadiene content in the stream after stripping is between 20 and 30 ppb (EPA-HQ-OPPT-2018-0451-0027).

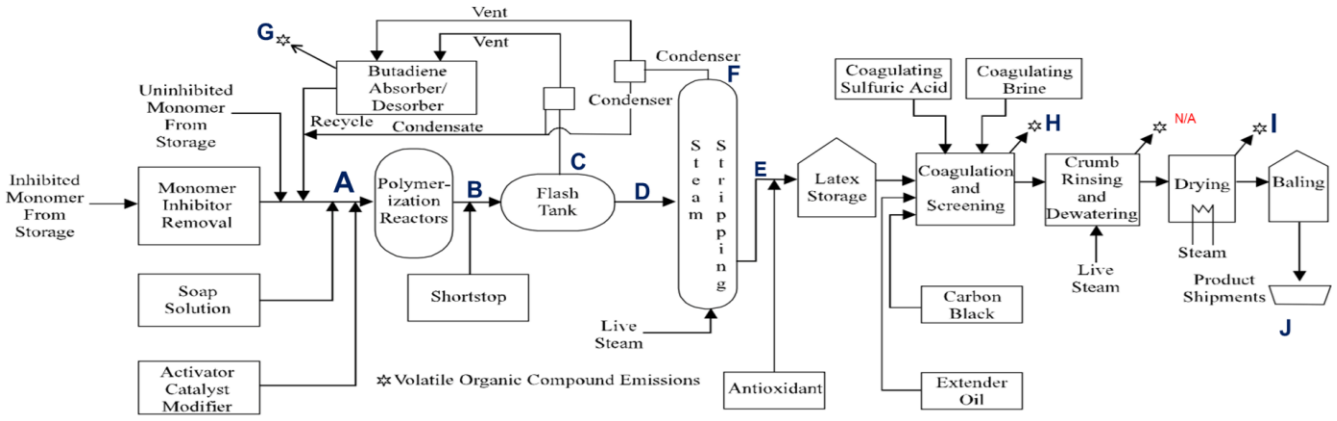


Figure 3-5. Illustration of a Typical Emulsion Process
Source: IISRP

3.5.2 Facility Estimates

EPA used TRI, NEI, and CDR data between 2016 and 2021 to identify 73 facilities that potentially use 1,3-butadiene during Plastics and rubber compounding. The IISRP estimates that 1,883,000 tons of butadiene-containing synthetic rubbers were compounded and converted. Of this capacity, 47.6 percent were styrene-butadiene rubbers, 33.2 percent were butadiene rubbers, 18.1 percent were styrene block copolymers, 1.3 percent were acrylonitrile butadiene rubbers, and an unknown percentage was styrene isoprene butadiene rubbers (EPA-HQ-OPPT-2018-0451-0003). The ESD on Plastic Additives estimates 78 to 428 metric tons of ABS produced per site per year (78,000–428,000 kg/site-yr) (OECD, 2009b). It was reported by ACC in 2018 that roughly 63 to 69 percent of 1,3-butadiene PV goes toward the production of polymers and copolymers such as polybutadiene and styrene-butadiene rubber. Taking the high estimate of PV from CDR (5 billion lb), it can be estimated that up to 3.45 billion lb of 1,3-butadiene goes toward activities that are covered by this OES (EPA-HQ-OPPT-2018-0451-0021).

Facilities that produce or handle 1,3-butadiene may have several uses for the chemical on-site. Despite this, for the purposes of this assessment each site can only be assigned one OES. The OES was chosen using professional judgment to reflect the most prominent activity according to TRI and NEI reporting and the information on the company website. Since deciding the "most prominent activity" is subjective, EPA developed a systematic approach to sorting these release sites in TRI (which was then adapted to NEI). Reviewing the company information for each facility was an important step in sorting a site into the Plastics and rubber compounding OES. If the company information indicated the production of a plastic/rubber product in which 1,3-butadiene is known to be involved in the compounding stage such as the products listed in the previous paragraph, the Plastics and rubber compounding OES was chosen. If a facility has a primary NAICS code of 325211 (Plastics Material and Resin Manufacturing) or 325212 (Synthetic Rubber Manufacturing), plastics and rubber compounding was assumed unless the company information indicated through the specific product produced that processing as a reactant was a more appropriate assignment.

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to plastic and rubber compounding that reported to CDR, TRI, and/or NEI.

EPA did not identify data on facility operating schedules. The ESD on Plastic Additives references European technical guidance, which estimates up to 300 operating days/yr for the polymers industry (OECD, 2009b). EPA assumes 300 days/yr of operation.

3.5.3 Release Assessment

3.5.3.1 Environmental Release Points

EPA expects releases to occur to air, water, incineration, or landfill from container transfers from connecting and disconnecting of hoses from trucks to storage tanks, container residue cleaning and disposal, vapor emissions from blending/compounding operation, equipment cleaning residue losses, direct contact cooling, and loading compounded plastics into final containers.

3.5.3.2 Environmental Release Assessment Results

EPA used 2016 to 2021 TRI, 2017 NEI, and 2020 NEI data to estimate environmental releases during the plastic and rubber compounding of 1,3-butadiene, as presented in Table 3-16. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, indirectly through the transfer to a non-POTW WWT facility, fugitive air, stack air, and land disposal.

Table 3-16. Summary of Environmental Releases During the Plastic and Rubber Compounding of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	22	51	300	7.5E−02	0.17	4	TRI
WWT	2.3	266		7.6E−03	0.89	3	TRI
Fugitive air	635	8,385		2.1	28	31	TRI
Fugitive air	453	8,048		1.7	22	65	NEI
Stack air	903	1.7E04		3.0	56	33	TRI
Stack air	142	9,294		0.43	33	65	NEI
Land	49	366		0.16	1.2	7	TRI

3.5.4 Occupational Exposure Assessment

3.5.4.1 Worker Activities

Worker exposures during the compounding process may occur via inhalation of vapors during unloading and loading and transport container cleaning (U.S. EPA, 2021c). PPE that may be worn at plastic compounding sites includes safety glasses, hard hats, flame retardant clothing, face shields, half-face respirators with organic cartridges, and chemical resistant coated gloves.

ONUs include supervisors, managers, and other employees that work in the compounding area but do not directly contact 1,3-butadiene received or processed onsite or handle compounded product. Therefore, EPA expects the ONUs to have lower inhalation exposures than workers who handle 1,3-butadiene or compounded products directly.

3.5.4.2 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 1,3-butadiene during plastic and rubber compounding (U.S. BLS, 2023). 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 includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 325211 – Plastics Material and Resin Manufacturing
- 325212 – Synthetic Rubber Manufacturing
- 325991 – Custom Compounding of Purchased Resins
- 326211 – Tire Manufacturing (except Retreading)
- 326220 – Rubber and Plastics Hoses and Belting Manufacturing
- 326299 – All Other Rubber Product Manufacturing
- 424690 – Other Chemical and Allied Products Merchant Wholesalers

Table 3-17 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.5.2.

Table 3-17. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Plastics and Rubber Compounding

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
73	325211 – Plastics Material and Resin Manufacturing	26	11
	325212 – Synthetic Rubber Manufacturing		
	325991 – Custom Compounding of Purchased Resins		
	326211 – Tire Manufacturing (except Retreading)		
	326220 – Rubber and Plastics Hoses and Belting Manufacturing		
	326299 – All Other Rubber Product Manufacturing		
	424690 – Other Chemical and Allied Products Merchant Wholesalers		

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

3.5.4.3 Occupational Inhalation Exposure Results

For plastics and rubber compounding, EPA identified one full-shift worker PBZ sample from OSHA CEHD. EPA combined this sample with analogous data from the Plastics converting OES. The plastics converting data included 53 8-hour and 44 12-hour full-shift worker PBZ samples from three different monitoring reports (USTMA, 2020; Lee et al., 2012; Roper, 1976). See Section 3.6.4.3 for additional information on these data. EPA did not identify any full-shift ONU PBZ samples during data evaluation. Therefore, EPA used the central tendency from workers to represent ONU exposures.

From the discrete monitoring data found through systematic review, EPA calculated the 50th and 95th percentile 8- and 12-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 3-18 and Table 3-20. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-18. 8-Hour Duration of Inhalation Exposures of Workers to 1,3-Butadiene During Plastic and Rubber Compounding

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Number of Samples	53		0	
8-hour TWA Exposure Concentrations	0.27	2.9E−02	2.9E−02	2.9E−02
Acute Exposure Concentrations (AC)	0.18	2.0E−02	2.0E−02	2.0E−02
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	0.14	1.4E−02	1.4E−02	1.4E−02
Average Daily Concentration (ADC)	0.13	1.4E−02	1.4E−02	1.4E−02
Lifetime Average Daily Concentration (LADC)	3.3E−02	2.7E−03	3.5E−03	2.7E−03

Table 3-19. 12-Hour Duration of Inhalation Exposures of Workers to 1,3-Butadiene During Plastic and Rubber Compounding

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Number of Samples	44		0	
12-hour TWA Exposure Concentrations	0.28	0.14	0.14	0.14
Acute Exposure Concentrations (AC)	0.28	0.14	0.14	0.14
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	0.21	0.11	0.11	0.11
Average Daily Concentration (ADC)	0.13	6.6E−02	6.6E−02	6.6E−02
Lifetime Average Daily Concentration (LADC)	3.2E−02	1.3E−02	1.6E−02	1.3E−02

3.6 Plastics and Rubber Converting

3.6.1 Process Description

After the compounding process described in Section 3.5, compounded plastic and rubber resins are converted into solid articles. For butadiene-containing plastics and rubbers, common converting processes include injection molding, extrusion, calendaring, blow molding, and thermoforming (Sun and Wristers, 2002). In injection molding, heated resin is injected into a cold mold where the plastic takes the shape of the mold as it solidifies. In extrusion, heated resin is forced through a die and then quenched to form products such as pipe, profiles, sheets, and wire coating. In calendaring, heated resin is fed onto rolls that compress the material into a thin layer to form sheets and films (OECD, 2009b). There are two types of blow molding that plastic and rubber producers use: extrusion and injection blow molding. In extrusion blow molding, an extruder delivers a tubular extrudate (parison) between two halves of a mold which are brought together around the hot extrudate, closing its top and bottom. Air is blown into the parison, forcing the polymer melt against the sides of the mold. In injection blow molding, the parison, usually in a preform shape, is formed by injection molding. The parison is normally transferred directly to a blow molding unit or it may be cooled and stored as a preform. In thermoforming, a plastic sheet is locked in a frame and is heated to the forming temperature when it is brought into contact with a mold whose shape it assumes. In some cases, the process is assisted by drawing the sheet on to the form using vacuum, in others, pressure is applied. For all methods, in some cases the plastic product may undergo subsequent trimming to remove excess material. Other finishing operations, such as paint, coating, and bonding may occur (these are covered under other conditions of use) (OECD, 2009b). Figure 3-6 below highlights typical release and exposure points during the use of 1,3-butadiene in plastics compounding.

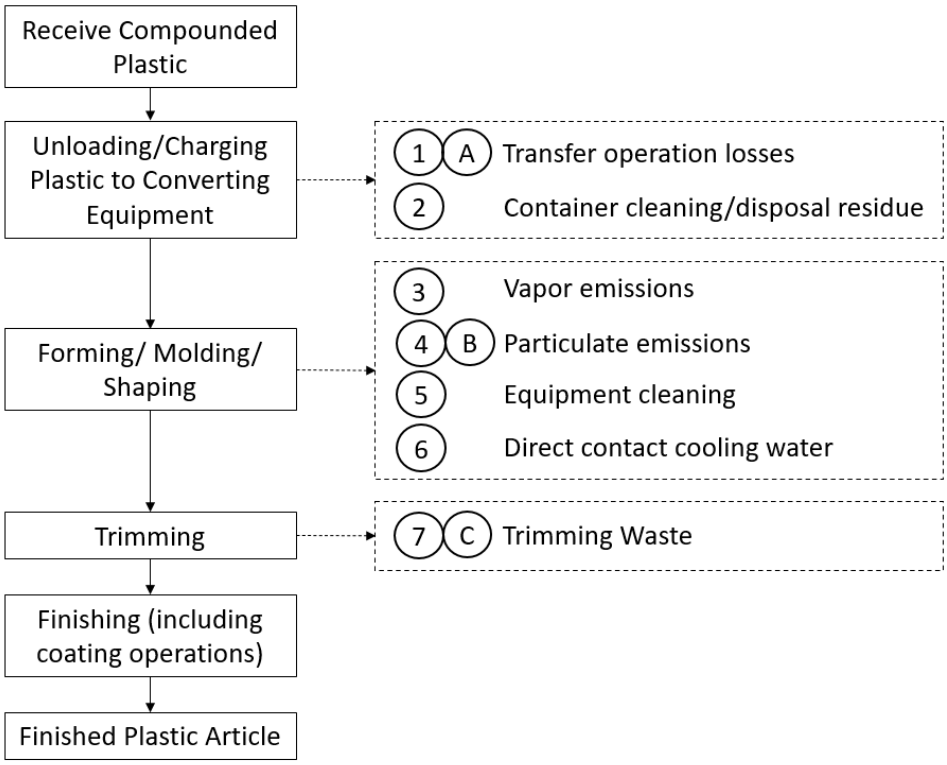


Figure 3-6. Typical Release and Exposure Points During Plastics Converting

Source: U.S. EPA, 2004

Environmental Releases:

1. Transfer operation losses to air, water, landfill or incineration from container transfers of compounded resin
2. Container residue cleaning/disposal losses to water, landfill, or incineration
3. Vapor emissions from converting to stack or fugitive air (liquid additives only)
4. Particulate emissions from converting to air, water, incineration, or landfill (all additive types)
5. Equipment cleaning losses to water, landfill, or incineration
6. Direct contact cooling water release to water
7. Solid waste from trimming operations to landfill or incineration

Occupational Exposure:

A. Inhalation exposures to solids during unloading of compounded resins
B. Inhalation exposure to dusts generated during converting processes
C. Inhalation exposure to solids during trimming activities

3.6.2 Facility Estimates

EPA used TRI, NEI, and CDR data between 2016 and 2021 to identify 77 facilities that potentially use 1,3-butadiene during plastic and rubber converting. IISRP estimates that 1,883 KT of butadiene-containing synthetic rubbers were compounded and converted. Of this capacity, 47.6 percent were styrene-butadiene rubbers, 33.2 percent were butadiene rubbers, 18.1 percent were styrene block copolymers, 1.3 percent were acrylonitrile butadiene rubbers, and an unknown percentage was styrene isoprene butadiene rubbers (EPA-HQ-OPPT-2018-0451-0022). The ESD on Plastic Additives estimates 78 to 428 metric tons of ABS produced per site per year (78,000–428,000 kg/site-yr) (OECD, 2009b). EPA did not identify any information on the concentration of 1,3-butadiene used in plastics and rubber converting, however as described in Section 3.5, 1,3-Butadiene concentrations at these sites are expected to be minimal at this point in the plastic and rubber manufacturing process.

Facilities that produce or handle 1,3-butadiene may have several uses for the chemical on-site. Despite this, for the purposes of our assessment each site can only be assigned to one OES. The OES was chosen

using professional judgment to reflect the most prominent activity according to TRI and NEI reporting and the information on the company website. Since deciding the "most prominent activity" is subjective, EPA developed a systematic approach to sorting these release sites in TRI (which was then adapted to NEI). If a facility had a primary NAICS code of 326113 (Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing), 326220 (Rubber and Plastics Hoses and Belting Manufacturing), 326299 (All Other Rubber Product Manufacturing), plastics and rubber converting was assumed.

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to plastic and rubber converting that reported to CDR, TRI, and/or NEI.

EPA did not identify data on facility operating schedules. The ESD on Plastic Additives references European technical guidance, which estimates up to 300 operating days/yr for the polymers industry (OECD, 2009b). EPA assumes 300 days/yr of operation.

3.6.3 Release Assessment

3.6.3.1 Environmental Release Points

EPA expects releases to occur to air, water, landfill, or incineration from container transfers of compounded resin, container residue cleaning/disposal, vapor emissions from converting, equipment cleaning. EPA also expects releases to wastewater from direct contact cooling and incineration, and landfill releases from solid waste trimming.

3.6.3.2 Environmental Release Assessment Results

EPA used 2016-2021 TRI, 2017 NEI, and 2020 NEI data to estimate environmental releases during the plastic and rubber converting of 1,3-butadiene, as presented in Table 3-20. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, fugitive air, stack air, and land disposal.

Table 3-20. Summary of Environmental Releases During the Plastic and Rubber Converting of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	– [a]	–	300	–	–	–	TRI
Fugitive air	113	215		0.38	0.72	1	TRI
Fugitive air	0.57	18		1.9E−03	7.3E−02	76	NEI
Stack air	113	215		0.38	0.72	2	TRI
Stack air	6	46		1.9E−02	0.14	76	NEI
Land	113	113		0.38	0.38	1	TRI

[a] Dashes indicate that no data was reported to the respective source for the method of release.

3.6.4 Occupational Exposure Assessment

3.6.4.1 Worker Activities

Workers are potentially exposed to 1,3-butadiene via inhalation during the converting process. Additionally, workers may be exposed to 1,3-butadiene via inhalation of vapors during unloading and loading, transport container cleaning, and trimming of excess plastic (U.S. EPA, 2021d). EPA identified examples of engineering controls used at some plastic converting sites during rubber mixing and curing, such as a local exhaust to control emissions and limit worker exposure; however, the Agency did not identify the extent to which these engineering controls are used at other plastic converting sites (USTMA, 2020). One monitoring report indicated that when exposure sampling occurred, workers sampled did not wear protective clothing or respirators (Anderson et al., 1996). However, this source was from 1996 and EPA did not identify the extent to which this is standard practice at all converting sites.

ONUs include supervisors, managers, and other employees that work in the converting area but do not directly contact the plastic and rubber additives or products. Therefore, EPA expects the ONUs to have lower inhalation exposures than workers who handle the plastic and rubber additives or products.

3.6.4.2 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 1,3-butadiene during plastics and rubber converting (U.S. BLS, 2023). This approach involved first identifying the relevant NAICS codes for the OES. The next step is the identification of relevant Standard Occupational Classification (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 includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 325212 – Synthetic Rubber Manufacturing
- 326100 – Plastics Product Manufacturing
- 326211 – Tire Manufacturing (except Retreading)
- 326220 – Rubber and Plastics Hoses and Belting Manufacturing
- 326299 – All Other Rubber Product Manufacturing

Table 3-21 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.6.2.

Table 3-21. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Plastics and Rubber Converting

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
77	325212 – Synthetic Rubber Manufacturing	18	12
	326100 – Plastics Product Manufacturing		
	326211 – Tire Manufacturing (except Retreading)		
	326220 – Rubber and Plastics Hoses and Belting Manufacturing		
	326299 – All Other Rubber Product Manufacturing		

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

3.6.4.3 Occupational Inhalation Exposure Results

For plastics and rubber converting, EPA identified full-shift PBZ worker samples from three different studies (USTMA, 2020; Lee et al., 2012; Roper, 1976), the first two having a high data quality rating from systematic review and the third having a medium rating due to the study's age and lack of statistics characterizing the uncertainty of the provided data. The studies collected samples from workers at various rubber product manufacturing sites, such as tire and tube manufacturing. The worker samples collected included bloc cutters, mill operators, lab operators, and chipper operators. From these datasets, EPA identified 50 8-hour samples and 44 12-hour samples (USTMA, 2020; Lee et al., 2012; Roper, 1976).

EPA did not identify any full-shift ONU PBZ samples during data evaluation. Therefore, the Agency used the central tendency from workers to represent ONU exposures.

From the discrete monitoring data found through systematic review, EPA calculated the 50th and 95th percentile 8- and 12-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 **3-22** and Table 3-23. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-22. 8-Hour Duration of Inhalation Exposures of Workers to 1,3-Butadiene During Plastics and Rubber Converting

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Number of Samples	50		0	
8-hour TWA Exposure Concentrations	0.29	2.5E−02	2.5E−02	2.5E−02

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Acute Exposure Concentrations (AC)	0.20	1.7E−02	1.7E−02	1.7E−02
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	0.14	1.2E−02	1.2E−02	1.2E−02
Average Daily Concentration (ADC)	0.14	1.2E−02	1.2E−02	1.2E−02
Lifetime Average Daily Concentration (LADC)	3.5E−02	2.3E−03	3.0E−03	2.3E−03

Table 3-23. 12-Hour Duration of Inhalation Exposures of Workers to 1,3-Butadiene During Plastic and Rubber Converting

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Number of Samples	44		0	
12-hour TWA Exposure Concentrations	0.29	9.1E−02	9.1E−02	9.1E−02
Acute Exposure Concentrations (AC)	0.29	9.3E−02	9.3E−02	9.3E−02
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	0.22	6.8E−02	6.8E−02	6.8E−02
Average Daily Concentration (ADC)	0.13	4.2E−02	4.2E−02	4.2E−02
Lifetime Average Daily Concentration (LADC)	3.4E−02	8.3E−03	1.1E−02	8.3E−03

3.7 Distribution in Commerce

3.7.1 Process Description

EPA expects that 1,3-butadiene and 1,3-butadiene-containing products are distributed throughout commerce from manufacturing sites to processing repackaging sites. Repackaging sites are expected to distribute 1,3-butadiene for laboratory use or other downstream uses. Liquified 1,3-butadiene is transported in pressurized containers via railroads or tankers, but also pipelines, ships, barges, and bulk liquid containers. Before transport, 1,3-butadiene is required to be inhibited. The current recognized inhibitor is tertiary butyl catechol (TBC). Also, to minimize the formation of peroxides in 1,3-butadiene during shipping and handling, the oxygen level in the vapor space of loaded equipment is not to exceed 1,000 ppm (EPA-HQ-OPPT-2018-0451-0021).

Distribution of 1,3-butadiene in commerce may include loading and unloading activities that occur during other life cycle stages (*e.g.*, manufacturing, processing, repackaging), transit activities that involve the movement of the chemical (*e.g.*, via trucks, railcars, barges), and temporary storage and warehousing of the chemical during distribution—excluding repackaging and other processing activities that are included in other COUs. In most cases EPA assessed the distribution in commerce activities

resulting in releases and exposures such as loading/unloading throughout the various life cycle stages and COUs rather than a single distribution scenario. The purpose of this OES is to present available data from accidental spills that have occurred during the transportation of 1,3-butadiene between facilities.

Figure 3-7 shows an illustration of the distribution in commerce. The illustration shows red shading indicating loading and unloading activities related to distribution in commerce included in the assessment of the COUs within other life cycle stages. The red arrows indicate transport activities of distribution in commerce, which include the transit via trucks, railcars, and barges, and any temporary storage or warehousing, relabeling, and redistribution. The transport activities are what connect the life cycle stages (manufacture, processing, use, and disposal) together.

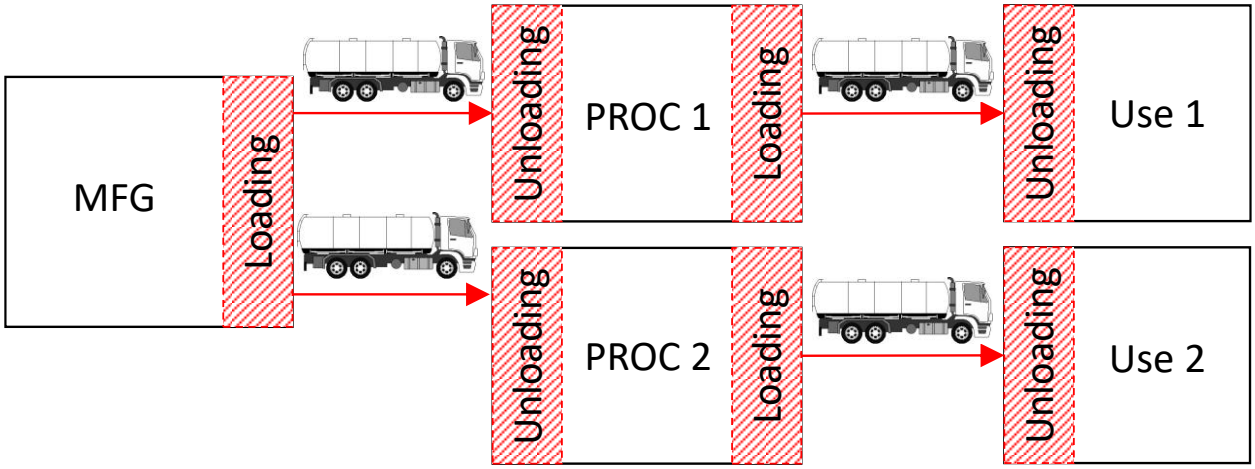


Figure 3-7. Illustration of Distribution in Commerce and its Relation to Other Life Cycle Stages

EPA did not identify data on the total volume of 1,3-butadiene distributed in commerce, nor volumes typically transported by a transportation company over any timeframe. As discussed above, because the Agency is not separately assessing releases and exposures in a single distribution in commerce scenario, EPA did not estimate 1,3-butadiene volumes or operating days for this condition of use.

3.7.2 Facility Estimates

Distribution in commerce involves transportation of 1,3-butadiene between facilities that manage 1,3-butadiene at the various life cycle stages. Other OESs address the facility information relevant to handling 1,3-butadiene in each of these life cycle stages. EPA did not quantify the number of transportation/warehousing companies or facilities, volume of 1,3-butadiene transported, or number of transport vehicles. The amount of 1,3-butadiene distributed in commerce will scale with the demand for 1,3-butadiene and 1,3-butadiene-containing products.

3.7.3 Release Assessment

3.7.3.1 Environmental Release Points

The main release source of 1,3-butadiene during distribution in commerce is accidental releases of the compound during spill events. When a spill occurs, it must first be evaluated to determine a plan of action for clean-up. Spill response cleanup times may vary depending on the severity, location, and additional hazards associated with the spill which may require additional special measures to be taken.

Spill response actions may include the following:[3]

- Installing fences, warning signs, or other security or site control precautions where humans or animals have access to the release;
- Drainage controls where needed to reduce migration of hazardous substances or pollutants off-site or to prevent precipitation or run-off from other sources;
- Stabilization of berms, dikes, or impoundments or drainage or closing of lagoons where needed to maintain the integrity of the structures;
- Capping of contaminated soils or sludges—where needed to reduce migration of hazardous substances or pollutants or contaminants into soil, ground or surface water, or air;
- Using chemicals and other materials to retard the spread of the release or to mitigate its effects—where the use of such chemicals will reduce the spread of the release;
- Excavation, consolidation, or removal of highly contaminated soils from drainage or other areas—where such actions will reduce the spread of, or direct contact with, the contamination;
- Removal of drums, barrels, tanks, or other bulk containers that contain or may contain hazardous substances or pollutants or contaminants—where it will reduce the likelihood of spillage; leakage; exposure to humans, animals, or food chain; or fire or explosion;
- Containment, treatment, disposal, or incineration of hazardous materials—where needed to reduce the likelihood of human, animal, or food chain exposure; or
- Provision of alternative water supply—where necessary immediately to reduce exposure to contaminated household water and continuing until such time as local authorities can satisfy the need for a permanent remedy.

Another strategy for spill cleanup, provided by the U.S. Department of Transportation (DOT), includes three main steps:[4]

1. sizing-up the spill;
2. containment and confinement; and
3. disposal.

The first step, sizing-up the spill, involves an assessment of the spill by response personnel to identify the hazardous substance and prevent the spill from spreading. This is a non-invasive attempt to gain an understanding of the severity of the event. Generally, responders would look for the following information:

- Identity of the materials;
- Amount of the release;
- Hazards associated with each material(s);
- Effects and risks on the public, property, and environment;
- Potential pathway of release—air, land, surface waters, or groundwater;
- Most appropriate measures for controlling the release to prevent/reduce the impact; and
- Safety measures to protect all response personnel.

To obtain this information, responders would use visual methods such as

- Types and numbers of containers or cargo tanks;
- Placards, labels, and markings on containers or transportation vehicles;

[3] 40 CFR 300.415 Hazardous Substance Response
[4] Traffic Incident Management in Hazardous Materials Spills in Incident Clearance. Chapter 4.0 Hazard Materials Incident Clearance Compliance Requirements.

- Vapors, clouds, run-offs, or suspicious substances;
- Biological indicators—dead vegetation, animals, insects, and fish; and
- Physical condition of containers.

In some cases, responders may need to utilize quantitative methods such as colorimetric tubes, pH paper, and Splifyter classifier strips to detect the presence or release of hazardous chemicals.

Once the hazardous substance release has been identified, first responders may perform limited cleanup activities by employing basic containment and confinement techniques. 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. Spill confinement techniques include mist knockdown/vapor suppression, diversion of the spill, diking, booming, absorbing, fencing, and damming. For smaller vehicular spills, one of the easiest control methods is the use of granular absorbents, oil absorbent pads, or universal absorbent pads. These items are readily available and effective for smaller spills.

Once cleanup of the spill has occurred, professional licensed firms should be contracted to perform disposal of the hazardous substance. First responders may improve the disposal process by mitigating the spill following a standard operating procedure (SOP). The SOP should account for how to mitigate the spill, package the waste for transport, and secure the waste until a licensed transportation and disposal company can pick it up.

3.7.3.2 Environmental Release Assessment Results

When evaluating releases related to distribution in commerce of 1,3-butadiene, EPA considered two sources: National Response Center (NRC) data and DOT data from the Hazmat Incident Report Search Tool.[5] EPA examined data corresponding to the 2016 to 2021 calendar years for these data sources.

Section 103 of CERCLA requires the person in charge of a vessel or an onshore or offshore facility immediately notify the NRC when a CERCLA hazardous substance is released at or above the reportable quantity (RQ) in any 24-hour period, unless the release is federally permitted.[6] The NRC is an emergency call center maintained and operated by the U.S. Coast Guard that fields initial reports for pollution and railroad incidents. Information reported to the NRC is available on the NRC website.[7]

EPA downloaded NRC data for the 2016-2021 calendar years and reviewed it for reports pertaining to distribution of 1,3-butadiene. Upon review, the Agency found that 26 of reported releases for 1,3-butadiene appeared to occur during distribution of the chemical. Note that loading and unloading activities are covered in other conditions of use, and incident reports during those activities are not included in the below totals. Information on these incidents is summarized in Table 3-24, noting amount is the estimate from initial reports.

[5] DOT Hazmat Incident Report Search Tool
[6] CERCLA 103 – Release Notification
[7] U.S. Coast Guard National Response Center

Table 3-24. Releases of 1,3-Butadiene from Spills, Reported to NRC between 2016 and 2021

Year of Incident	Amount Released (lb, unless otherwise noted)	Type of Incident	State
2016	48	VESSEL	TX
2016	UNKNOWN AMOUNT	RAILROAD	TN
2016	2 (gallons)	MOBILE	CO
2016	UNKNOWN AMOUNT	RAILROAD	AR
2016	UNKNOWN AMOUNT	RAILROAD	AL
2017	1	VESSEL	LA
2017	UNKNOWN AMOUNT	VESSEL	LA
2017	UNKNOWN AMOUNT	RAILROAD	TN
2017	UNKNOWN AMOUNT	RAILROAD	OH
2017	UNKNOWN AMOUNT	RAILROAD	TX
2017	UNKNOWN AMOUNT	RAILROAD	LA
2017	UNKNOWN AMOUNT	MOBILE	NC
2018	UNKNOWN AMOUNT	RAILROAD	OH
2018	261	MOBILE	LA
2018	0.5 (cups)	VESSEL	LA
2018	UNKNOWN AMOUNT	RAILROAD	OH
2018	17.5	PIPELINE	TX
2019	10	MOBILE	TX
2019	UNKNOWN AMOUNT	VESSEL	IL
2019	UNKNOWN AMOUNT	RAILROAD	LA
2019	UNKNOWN AMOUNT	PIPELINE	TX
2019	UNKNOWN AMOUNT	RAILROAD	LA
2020	10	PIPELINE	LA
2020	10	VESSEL	TX
2021	UNKNOWN AMOUNT	RAILROAD	WV
2021	UNKNOWN AMOUNT	RAILROAD	TN

It is important to note that the data reported to NRC in the past does not correlate to possible spills in the future. Due to the lack of correlation, EPA is unable to estimate the frequency or volume of any spills that may occur in the future or provide estimates representative of a "typical" spill, as each spill represents a unique scenario.

EPA downloaded DOT data from the Hazmat Incident Report Search Tool for the 2016 to 2021 calendar years and reviewed it for reports pertaining to distribution of 1,3-butadiene. Upon review, EPA found four reported releases for 1,3-butadiene that appeared to occur during distribution of the chemical. Note that loading and unloading activities are covered in other conditions of use, and incident reports during those activities are not included in the below totals. Information on these incidents is summarized in

Table 3-25, noting amount is the estimate from initial reports.

Table 3-25. Releases of 1,3-Butadiene Reported to DOT between 2016 and 2021 through the Hazmat Incident Report Search Tool

Year of Incident	Amount Released (cubic foot of gas)	Type of Incident	State
2016	0.013368	Rail	TN
2019	0.13368	Rail	TX
2019	0.26736	Rail	LA
2021	0.000017	Rail	TX

3.7.4 Occupational Exposure Assessment

EPA did not identify data to estimate the magnitude or frequency of worker exposures from spill cleanup activities occurring from distribution in commerce of 1,3-butadiene. The Agency expects the magnitude of exposure to be dependent on the size and location of the spill and may have large variability. For example, the 0.5 cups spilled from a vessel in Louisiana cited in Table 3-25 above may have resulted in relatively low exposures due to the small volume of 1,3-butadiene released, whereas a much larger spill, such as the 261 lb spilled from a mobile source in the same state may result in significantly higher exposures to cleanup workers.

EPA expects that individual workers would be exposed to clean-up of spills of any one chemical during distribution in commerce about once per year with a worst-case scenario involving the same worker performing multiple spill cleanups of the same chemical in a year. However, similar to the magnitude of exposures, the duration of spill cleanups is expected to be dependent on the specifics of each chemical spill and could take minutes or days after the spill event to complete.

3.8 Use of Laboratory Chemicals

3.8.1 Process Description

The final scope for 1,3-butadiene lists laboratory use as an in-scope COU (U.S. EPA, 2020c). A safety data sheet (SDS) for 1,3-butadiene (>99% percent purity) indicates recommended use as a laboratory chemical. Specific uses include demonstration of Diels Alder reactions, synthesis of thermoplastic resins, and synthesis of disilylated dimers by reacting with chlorosilanes (Sigma-Aldrich, 2024). EPA did not find specific container information for 1,3-butadiene used in laboratories; however, EPA expects 1,3-butadiene to arrive as a pressurized liquid in drums or smaller containers received from the manufacturer or repackager. 1,3-Butadiene is used in these laboratory procedures and then disposed of with other laboratory wastes. Figure 3-8 below highlights the typical release and exposure points during the use of 1,3-butadiene as a laboratory chemical.

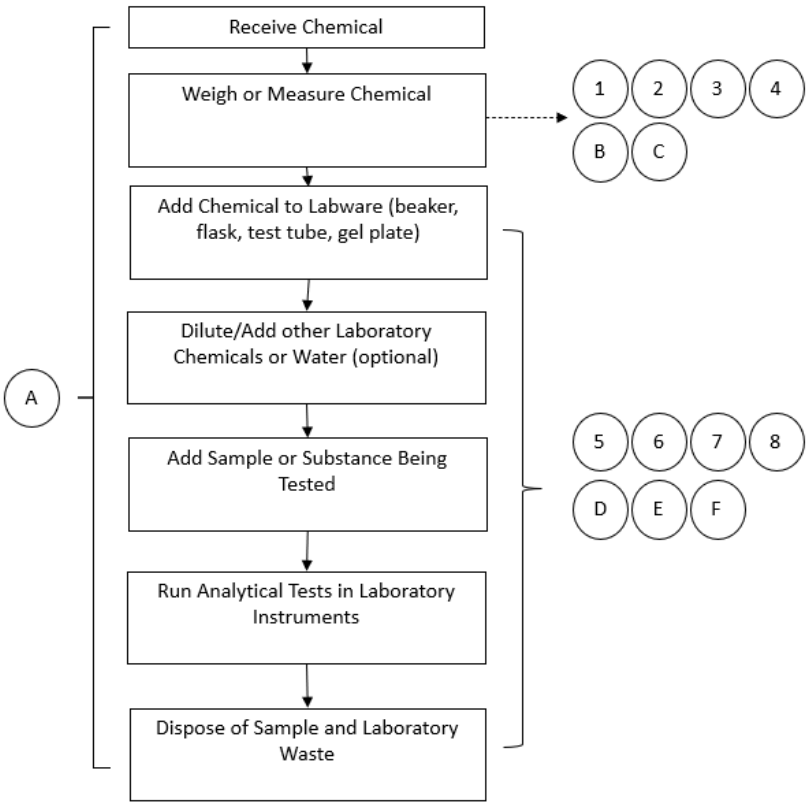


Figure 3-8. Typical Release and Exposure Points During the Laboratory Use of 1,3-Butadiene

Source: U.S. EPA, 2023

Environmental Releases:

1. Release to air from transferring volatile chemicals from transport containers.
2. Release to air, water, incineration, or landfill from transferring solid powders.
3. Release to water, incineration, or land from cleaning or disposal of transport containers.
4. Release to air from cleaning containers used for volatile chemicals.
5. Labware equipment cleaning residuals released to water, incineration, or landfill.
6. Release to air during labware equipment cleaning for volatile chemicals.
7. Release to air from laboratory analyses for volatile chemicals.
8. Release to water, incineration, or landfill from laboratory waste disposal.

Occupational Exposures:

A. Full-shift inhalation exposure from all activities.
B. Inhalation exposure from unloading chemicals from transport containers (if full-shift estimates are not used).
C. Inhalation exposure during container cleaning throughout sample preparation and testing activities (if full-shift estimates are not used).
D. Inhalation exposure during equipment cleaning (if full-shift estimates are not used).
E. Inhalation exposure during laboratory analyses (if full-shift estimates are not used).
F. Inhalation exposure during disposal of laboratory chemicals (non-quantifiable).

3.8.2 Facility Estimates

Between 2017 and 2020, EPA used NEI to identify five facilities that potentially use 1,3-butadiene as a laboratory chemical (no facilities were found in TRI or CDR). EPA did not identify data on facility operating schedules; therefore, EPA assumes operation 5 days/week for 50 weeks/yr. This results in 250 days/yr of operation (see Section 2.3.2).

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to use as a laboratory chemical that reported to CDR, TRI, and/or NEI.

3.8.3 Release Assessment

3.8.3.1 Environmental Release Points

EPA expects releases to air, water, incineration, or landfill from transferring volatile chemicals from transport containers, cleaning or disposal of transport containers, cleaning containers used for volatile chemicals, labware equipment cleaning residuals, labware equipment cleaning, laboratory analyses, and laboratory waste disposal.

3.8.3.2 Environmental Release Assessment Results

EPA used 2016-2021 TRI, 2017 NEI, and 2020 NEI to estimate environmental releases during the use of 1,3-butadiene as a laboratory chemical, as presented in

Table 3-26. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, fugitive air, stack air, and land disposal.

Table 3-26. Summary of Environmental Releases for the Use as Laboratory Chemical of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	–[a]	–	250	–	–	–	TRI
Fugitive air	–	–		–	–	–	TRI
Fugitive air	6.4E−02	6.3		2.6E−04	2.5E−02	5	NEI
Stack air	–	–		–	–	–	TRI
Stack air	37	53		0.1	0.14	5	NEI
Land	–	–		–	–	–	TRI

[a] Dashes indicate that no data was reported to the respective source for the method of release.

3.8.4 Occupational Exposure Assessment

3.8.4.1 Worker Activities

Worker exposures to 1,3-butadiene may occur through the inhalation of vapors while unloading and transferring laboratory chemicals, container cleaning, labware and labware equipment cleaning, laboratory analysis, and disposal of laboratory wastes (U.S. EPA, 2023). EPA did not find information on the extent to which laboratories that use 1,3-butadiene-containing chemicals also use engineering controls and/or worker PPE.

ONUs include supervisors, managers, and other employees that do not directly handle the laboratory chemical or laboratory equipment but may be present in the laboratory or analysis area. ONU inhalation exposures may occur while the ONU is present in the laboratory; however, EPA expects the ONUs to have lower inhalation exposures than workers who handle the laboratory chemicals and perform the analyses.

3.8.4.2 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 1,3-butadiene during use of laboratory chemicals (U.S. BLS, 2023). 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 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
- 541712 – Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)

Table 3-27 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.8.2.

Table 3-27. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Use as a Laboratory Chemical

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
5	541380 – Testing Laboratories	2	2
	541712 – Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)		

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

3.8.4.3 Occupational Inhalation Exposure Results

EPA did not identify monitoring data for the Laboratory use OES; however, EPA expects the exposures to be similar to laboratory technician worker activities during the Manufacturing OES. Therefore, EPA used the manufacturing monitoring data as "analogous data" for laboratory use. EPA refers to analogous monitoring data as monitoring data for the same chemical and a similar OES.

EPA identified 215 full-shift laboratory technician PBZ samples from the ACC industrial hygiene report (ToxStrategies, 2021). The laboratory technicians are responsible for sample collection and chemical analysis of process and product samples for the facility. The Agency did not identify any full-shift ONU PBZ samples during data evaluation. Therefore, EPA used the central tendency from workers to represent ONU exposures.

EPA compiled the 50th and 95th percentile 8-hour and 12-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 3-28. The Agency calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-28. Inhalation Exposures of Workers to 1,3-Butadiene During Use as a Laboratory Chemical, Based on ACC Data

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Number of Samples	215		39	
8-Hour TWA Exposure Concentrations	9.4E−02	6.3E−02	1.7E−02	8.0E−03
Acute Exposure Concentrations (AC)	6.4E−02	4.3E−02	1.2E−02	5.4E−03
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	4.7E−02	3.1E−02	8.5E−03	4.0E−03
Average Daily Concentration (ADC)	4.6E−02	3.1E−02	8.2E−03	3.9E−03
Lifetime Average Daily Concentration (LADC)	1.1E−02	5.9E−03	2.1E−03	7.6E−04

3.9 Application of Paints and Coatings

3.9.1 Process Description

The final scope for 1,3-butadiene lists that the chemical is used in industrial and commercial application of paints and coatings (U.S. EPA, 2020c). 1,3-Butadiene was identified as possibly being present in multiple paint and coating products, including aerosol propellants, architectural paints and coatings, latex paints, electro-dipping coatings, and automotive primers (ACA, 2019; OECD, 2009c).

The application procedure depends on the type of paint, or coating formulation and the type of substrate. In some types of application, the formulation is loaded into the application reservoir or apparatus and applied to the substrate via brush, spray, roll, dip, curtain, or syringe or bead application. Application may be manual or automated. After application, the adhesive, sealant, paint, or coating is allowed to dry or cure (OECD, 2015b). The drying/curing process may be promoted through the use of heat or radiation (radiation can include ultraviolet (UV) and electron beam radiation (OECD, 2010). EPA did not find specific container information for 1,3-butadiene used in the application of paints, coatings, adhesives, and sealants. A diagram of the radiation curable application process is show below in Figure 3-9.

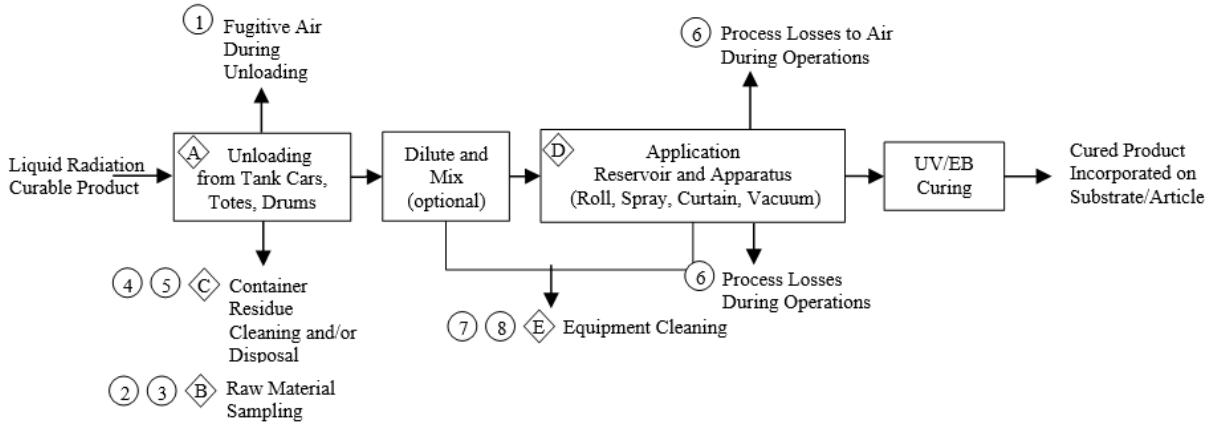


Figure 3-9. General Radiation Curable Coating Process

Source: OECD, 2011b

Environmental Releases:

1. Transfer operation losses of volatilized 1,3-butadiene to air from unloading the radiation curable product.
2. Raw material sampling losses to water, incineration, or landfill.
3. Open surface losses of volatilized 1,3-butadiene to air during raw material sampling.
4. Container residue losses to water, incineration, or landfill from radiation curable product transport containers.
5. Open surface losses of volatilized 1,3-butadiene to air during container cleaning.
6. Process losses to air from vented or captured overspray during spray coating operations. Process losses to water, land, or incineration from disposal of spent coating during roll, spray, or curtain coating.
7. Equipment cleaning losses to incineration or landfill.
8. Open surface losses of volatilized 1,3-butadiene to air during equipment cleaning.

Occupational Exposures:

A. Inhalation exposure from unloading chemicals from transport containers.
B. Inhalation exposure during sampling activities.
C. Inhalation exposure during container cleaning.
D. Inhalation exposure during coating application
E. Inhalation exposure during equipment cleaning.

The American Coatings Association noted in a public comment that "Manufacturers note residual amounts of the chemical in … architectural paints and coatings" (EPA-HQ-OPPT-2018-0451-0005). Substances in Preparations in Nordic Countries (SPIN) identified use of 1,3-butadiene in paints, lacquers and varnishes up to year 2016 in Nordic countries. SPIN also identifies use of 1,3-butadiene in surface treatment in Nordic countries up to year 2016.

EPA initially identified two paints and coatings products containing 1,3-butadiene—including an asphalt emulsion coating and a shellac sealer—however, upon further investigation and discussions the manufacturers, 1,3-butadiene was erroneously reported on the SDSs for the products. Despite the lack of products, 1,3-butadiene releases are still present at some NEI facilities mapped to the Paints and coatings OES, indicating 1,3-butadiene's presence in the industry.

3.9.2 Facility Estimates

EPA used 2017 and 2020 NEI data to identify 28 facilities that potentially use 1,3-butadiene during the application of paints and coatings (no facilities were found in TRI or CDR). The Agency did not locate any chemical-specific throughputs or use rates for 1,3-butadiene in the application of paints and coatings. However, typical consumption rates of coating components in automobile refinishing are provided in the ESD on the Coating Industry. To coat the whole body of a vehicle, 0.62 to 9.0 L of coating are needed, depending on the size of the vehicle. The average annual facility use rate for all automotive refinishing coating products is 54,633,000 gallons/yr, and the estimated daily volume use

rate per site is 0.25 to 15 gallons of coating/site-day (OECD, 2011a, 2009c).

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to application of paints and coatings that reported to CDR, TRI, and/or NEI.

EPA did not identify data on facility operating schedules. The ESD on the Application of Radiation Curable Coatings, Inks, and Adhesives provides an estimate of 250 operating days/yr (OECD, 2010).

3.9.3 Release Assessment

3.9.3.1 Environmental Release Points

Environmental releases may occur during the processes of unloading, material sampling, transport, container cleaning, air that is vented or captured during the spray operation, during the drying or curing processes, and during the cleaning and disposal of equipment. EPA expects releases to wastewater, incineration, or landfill from small container residue, equipment cleaning waste, application process waste, and trimming waste.

3.9.3.2 Environmental Release Assessment Results

EPA used 2016 to 2021 TRI, 2017 NEI, and 2020 NEI data to estimate environmental releases during the use of 1,3-butadiene in the application of paints, coatings, adhesives, and sealants, as presented in Table 3-29. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, fugitive air, stack air, incineration, and land disposal.

Table 3-29. Summary of Environmental Releases of 1,3-Butadiene During Use in the Application of Paints and Coatings

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	–[a]	–	250	–	–	–	TRI
Fugitive air	–	–		–	–	–	TRI
Fugitive air	0.20	31		5.7E−04	0.12	28	NEI
Stack air	–	–		–	–	–	TRI
Stack air	13	370		4.4E−02	1.1	14	NEI
Land	–	–		–	–	–	TRI

[a] Dashes indicate that no data was reported to the respective source for the method of release.

3.9.4 Occupational Exposure Assessment

3.9.4.1 Worker Activities

During the use of 1,3-butadiene-containing paints and coatings, workers are potentially exposed to 1,3-butadiene mist when roll, curtain, or spray coating. Vapor inhalation exposures for workers may also occur during product unloading, raw material sampling, application, and container and equipment cleaning (OECD, 2011b). EPA did not find information on the extent to which engineering controls and worker PPE are used at facilities that apply 1,3-butadiene-containing paints and coatings.

For this OES, ONUs would include supervisors, managers, and other employees that do not directly handle paint or coating equipment but may be present in the spray application area. EPA expects the ONUs to have lower inhalation exposures than workers who handle the paint and coating products.

3.9.4.2 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 1,3-butadiene during the application of paints and coatings (U.S. BLS, 2023). 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 includes further details regarding methodology for estimating the number of workers and ONUs per site. EPA assigned the following NAICS codes for this OES:

- 337110 – Wood Kitchen Cabinet and Countertop Manufacturing
- 337122 – Nonupholstered Wood Household Furniture Manufacturing
- 337124 – Metal Household Furniture Manufacturing
- 337127 – Institutional Furniture Manufacturing
- 337211 – Wood Office Furniture Manufacturing
- 337212 – Custom Architectural Woodwork and Millwork Manufacturing
- 337214 – Office Furniture (except Wood) Manufacturing
- 337215 – Showcase, Partition, Shelving, and Locker Manufacturing
- 811120 – Automotive Body, Paint, Interior, and Glass Repair

Table 3-30 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.9.2.

Table 3-30. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Applications of Paints and Coatings

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
228 (median) 1,530 (high end)	337110 – Wood Kitchen Cabinet and Countertop Manufacturing	8	3
	337122 – Nonupholstered Wood Household Furniture Manufacturing		
	337124 – Metal Household Furniture Manufacturing		
	337127 – Institutional Furniture Manufacturing		
	337211 – Wood Office Furniture Manufacturing		
	337212 – Custom Architectural Woodwork and Millwork Manufacturing		
	337214 – Office Furniture (except Wood) Manufacturing		
	337215 – Showcase, Partition, Shelving, and Locker Manufacturing		

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
	811120 – Automotive Body, Paint, Interior, and Glass Repair		

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

3.9.4.3 Occupational Inhalation Exposure Results

For exposure during the application of paints and coatings containing 1,3-butadiene, EPA identified 43 worker PBZ samples from OSHA CEHD (accessed via https://www.osha.gov/opengov/health-samples). The data spanned five facilities ranging from 2000 to 2016. However, all samples tested were below the reportable limit of detection (LOD). Based on facility information, EPA assumes that butadiene is present in the paint, coating, adhesive, or sealant formulations used at the facilities. Therefore, the Agency assessed the high-end inhalation exposures as the LOD and the central tendency as the LOD/2. The LOD was from the OSHA 56 air sampling method for 1,3-butadiene. EPA did not identify any ONU PBZ samples during data evaluation. Therefore, the Agency 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 3-31. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-31. Inhalation Exposures of Workers to 1,3-Butadiene During Use of Paints and Coatings, Based on OSHA Data

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Number of Samples	43		0	
8-hour TWA Exposure Concentrations	9.0E−02	4.5E−02	4.5E−02	4.5E−02
Acute Exposure Concentrations (AC)	6.2E−02	3.1E−02	3.1E−02	3.1E−02
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	4.5E−02	2.3E−02	2.3E−02	2.3E−02
Average Daily Concentration (ADC)	4.4E−02	2.2E−02	2.2E−02	2.2E−02
Lifetime Average Daily Concentration (LADC)	1.1E−02	4.3E−03	5.5E−03	4.3E−03

3.10 Application of Adhesives and Sealants

3.10.1 Process Description

The final scope for 1,3-butadiene lists that the chemical is used in industrial and commercial application of adhesives and sealants (U.S. EPA, 2020c). 1,3-Butadiene was identified in multiple adhesive and sealant products, including aerosol propellants, epoxy resins (incorporated for their tensile and

elastomeric properties), and adhesives for electrical and circuit boards (ACA, 2019; OECD, 2009c), (EPA-HQ-OPPT-2018-0451-0009).

The application procedure depends on the type of adhesive or sealant formulation and the type of substrate. In some types of application, the formulation is loaded into the application reservoir or apparatus and applied to the substrate via brush, spray, roll, dip, curtain, or syringe or bead application. Application may be manual or automated. After application, the adhesive, sealant, paint, or coating is allowed to dry or cure (OECD, 2015b). The drying/curing process may be promoted through the use of heat or radiation; the latter can include ultraviolet [UV] light and electron beam radiation (OECD, 2010). EPA did not find specific container information for 1,3-butadiene used in the application of adhesives and sealants. A diagram of the radiation curable application process is shown in Figure 3-9 in the previous section is also applicable to describing possible releases and exposures due to application of adhesives and sealants.

EPA initially identified four adhesive and sealant products that contained 1,3-butadiene. Upon further investigation and discussions with the manufacturers, it was confirmed that all but one of these products had reported the presence of 1,3-butadiene erroneously. The remaining product is a tire patch that contains 23 to 24 percent 1,3-butadiene (Highline Warren, 2015).

3.10.2 Facility Estimates

EPA used 2017 and 2020 NEI data to identify one facility that potentially uses 1,3-butadiene during the application of adhesives and sealants (no facilities were found in TRI or CDR). Since a single site would not provide a representative sample of the possible releases of facilities that may use 1,3-butadiene in the application of adhesives and sealants, EPA used NAICS codes and Monte Carlo modeling to determine a reasonable estimate for the number of facilities. The range of the number of facilities, representing the 50th and 95th percentiles estimated using Monte Carlo modeling was 60 to 1,133 sites.

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to application of adhesives and sealants that reported to CDR, TRI, and/or NEI.

EPA estimated the PV for the application of adhesives and sealants OES using the national production range according to 2020 CDR data, an ACC report detailing 1,3-butadiene use, and a technical report estimating air emissions of 1,3-butadiene (ToxStrategies, 2021; U.S. EPA, 2020a, 1996). The ACC report provided conversion rates for several end formulation product types including, but not limited to, styrene-butadiene rubber, adiponitrile, and neoprene rubber (EPA-HQ-OPPT-2018-0451-0041). U.S. EPA, 1996 provided a percentage breakdown of 1,3-butadiene use within each formulation product type for specific end use categories, including adhesives and sealants. EPA used the conversion rate and end use percentages with the 2020 CDR PV range (1–5 billion lb) to estimate the PV for use within the application of adhesives and sealants OES. Based on this calculation, the estimated range for the application of adhesives and sealants OES is 339,000 to 7,820,000 lb. Table 3-32 provides the PV estimation for the application of adhesives and sealants.

Table 3-32. Production Volume Estimation for Application of Adhesives and Sealants OES

Formulation Product Type	Formulation Product Percentage of Production Volume (%)	Adhesive and Sealant Use Rate (%)	Formulation Product Conversion Rate	Production Volume (lb)	Rationale
Styrene-Butadiene Rubber	30	3	0.999	9,000 to 45,000	According to ACC, the butadiene monomer is recovered and recycled during the manufacturing process. It is assumed that only 0.001% of the butadiene used in the SBR manufacturing process is present as residual in the final product (EPA-HQ-OPPT-2018-0451-0041).
Polybutadiene	20	N/A – no adhesive and sealant use	n/a	n/a	No adhesive and sealant use expected using this polymer.
Adiponitrile	15	N/A – no adhesive and sealant use	n/a	n/a	No adhesive and sealant use expected using this polymer.
Styrene-Butadiene Latex	10	N/A – no adhesive and sealant use	n/a	n/a	No adhesive and sealant use expected using this polymer.
Neoprene Rubber	5	12	0.95	300,000 to 1,500,000	According to the EPA published technical report, the conversion rate of 1,3-butadiene in the Chloroprene/Neoprene manufacturing process is 95%. (U.S. EPA, 1996)
ABS Resin	5	N/A – no adhesive and sealant use	n/a	n/a	No adhesive and sealant use expected using this polymer.
Nitrile Rubber	5	10	0.999	5,000 to 25,000	According to the EPA published technical report, the conversion rate of 1,3-butadiene in the nitrile rubber manufacturing process ranges from 75-90%. However, the source also indicates that unreacted monomer is reacted and recycled into the manufacturing stream. Assume that a maximum of 0.001% 1,3-butadiene is residual in the product stream (U.S. EPA, 1996).
Miscellaneous	10	25	0.95 to 0.999	25,000 to 6,250,000	SBS and SEBS polymers are assumed to fall under the miscellaneous polymer use category. 1,3-Butadiene conversion was estimated by

Formulation Product Type	Formulation Product Percentage of Production Volume (%)	Adhesive and Sealant Use Rate (%)	Formulation Product Conversion Rate	Production Volume (lb)	Rationale
					taking the reported range of all other polymer conversion percentages used in PV estimation (U.S. EPA, 1996).

EPA did not find any chemical-specific throughputs or use rates for 1,3-butadiene in the application of adhesives and sealants. The annual throughput of adhesive and sealant product is modeled using a triangular distribution with a lower bound of 1,000 kg/yr, an upper bound of 1,000,000 kg/yr, and mode of 13,500 kg/yr. This is based on the ESD on the Use of Adhesives (OECD, 2015b). That ESD provides default adhesive use rates based on end-use category. EPA compiled the end-use categories that were relevant to downstream uses for adhesives and sealants containing 1,3-butadiene—which included general assembly, motor and non-motor vehicles, vehicle parts, tire manufacturing (except retreading), and computer/electronic and electrical product manufacturing. The lower and upper bound adhesive use rates for these categories was 1,000 to 1,000,000 kg/yr. The mode is based on the ESD default for unknown end-use markets.

EPA modeled the operating days per year using a triangular distribution with a lower bound of 50 days/yr, an upper bound of 365 days/yr, and a mode of 260 days/yr. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 50 to 365 days/yr. This is based on the ESD on Use of Adhesives (OECD, 2015b).

3.10.3 Release Assessment

3.10.3.1 Environmental Release Points

Environmental releases may occur during the processes of unloading, material sampling, transport, container cleaning, air that is vented or captured during the spray operation, during the drying or curing process, and during the cleaning and disposal of equipment. EPA expects releases to wastewater, incineration, or landfill from small container residue, equipment cleaning waste, adhesive application process waste, and trimming waste.

3.10.3.2 Environmental Release Assessment Results

EPA estimated releases using a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method using the models and approaches described in Appendix D for this OES. Input parameters for the models were determined using data from literature and the ESD on the Industrial Use of Adhesives for Substrate Bonding (OECD, 2013). Table 3-33 summarizes the estimated release results for 1,3-butadiene use in adhesives and sealants based on the scenario applied. The high-ends are the 95th percentile of the respective simulation output and the central tendencies are the 50th percentile.

Table 3-33. Summary of Environmental Releases in the Application of Adhesives and Sealants Use of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range (kg-site/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/site-day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Fugitive or stack air	19	205	250	0.11	1.0	2 – 299,581 generic sites	Monte Carlo Modeling
Stack air	108	108		0.41	0.43	1	NEI
Incineration or Landfill	589	2,878		2.7	15	2 – 299,581 generic sites	Monte Carlo Modeling
Air, Incineration, or Landfill	2.7E04	1.2E05		124	631	2 – 299,581 generic sites	Monte Carlo Modeling

3.10.4 Occupational Exposure Assessment

3.10.4.1 Worker Activities

During the use of adhesives and sealants containing 1,3-butadiene, worker exposures to 1,3-butadiene mist may occur while spraying or roll coating adhesives and sealants. Worker exposures may also occur via inhalation of vapors during product unloading, product container cleaning, application equipment cleaning, and curing or drying (OECD, 2015a). EPA did not identify information on engineering controls or worker PPE used at 1,3-butadiene-containing adhesive and sealant sites.

ONUs include supervisors, managers, and other employees that work in the application area but do not directly handle or apply 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.

3.10.4.2 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 1,3-butadiene during application of adhesives and sealants (U.S. BLS, 2023). 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 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
- 334100 – Computer and Peripheral Equipment Manufacturing
- 334200 – Communications Equipment Manufacturing
- 334300 – Audio and Video Equipment Manufacturing
- 334400 –Semiconductor and Other Electronic Component Manufacturing
- 334500 – Navigational, Measuring, Electromedical, and Control Instruments Manufacturing

- 334600 – Manufacturing and Reproducing Magnetic and Optical Media
- 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
- 336500 – Railroad Rolling Stock Manufacturing
- 336600 – Ship and Boat Building
- 336900 – Other Transportation Equipment Manufacturing

Table 3-34 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.10.2.

Table 3-34. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Application of Adhesives and Sealants

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
60 (median) 1,133 (high-end)	322220 – Paper Bag and Coated and Treated Paper Manufacturing	51	7
	334100 – Computer and Peripheral Equipment Manufacturing		
	334200 – Communications Equipment Manufacturing		
	334300 – Audio and Video Equipment Manufacturing		
	334400 –Semiconductor and Other Electronic Component Manufacturing		
	334500 – Navigational, Measuring, Electromedical, and Control Instruments Manufacturing		
	334600 – Manufacturing and Reproducing Magnetic and Optical Media		
	335100 – Electric Lighting Equipment Manufacturing		
	335200 – Household Appliance Manufacturing		
	335300 – Electrical Equipment Manufacturing		
	335900 – Other Electrical Equipment and Component Manufacturing		
	336100 – Motor Vehicle Manufacturing		

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
	336200 – Motor Vehicle Body and Trailer Manufacturing		
	336300 – Motor Vehicle Parts Manufacturing		
	336400 – Aerospace Product and Parts Manufacturing		
	336500 – Railroad Rolling Stock Manufacturing		
	336600 – Ship and Boat Building		
	336900 – Other Transportation Equipment Manufacturing		

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

3.10.4.3 Occupational Inhalation Exposure Results

For exposure during the application of adhesives and sealants containing 1,3-butadiene, EPA used the same dataset referenced in Section 3.9.4.3. This approach was taken because the Agency cannot distinguish whether the data pertained specifically to paints and coatings, or to adhesives and sealants. Due to the lack of discrete sample data above the reportable LOD, EPA assessed the high-end estimate to be equal to the LOD and the central tendency equivalent to half of the LOD.

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 3-35. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-35. Inhalation Exposures of Workers to 1,3-Butadiene During Application of Adhesives and Sealants

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
8-hour TWA Exposure Concentrations	9.0E−02	4.5E−02	4.5E−02	4.5E−02
Acute Exposure Concentrations (AC)	6.2E−02	3.1E−02	3.1E−02	3.1E−02
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	4.5E−02	2.3E−02	2.3E−02	2.3E−02
Average Daily Concentration (ADC)	4.4E−02	2.2E−02	2.2E−02	2.2E−02
Lifetime Average Daily Concentration (LADC)	1.1E−02	4.3E−03	5.5E−03	4.3E−03

3.11 Use in Fuels and Related Products

3.11.1 Process Description

The 2016 CDR submission from one reporter indicated a 2014 PV of 183,032,673 lb of gaseous 1,3-butadiene for fuels and related products at concentrations of at least 1 but less than 30 percent by weight (U.S. EPA, 2016). In addition, the European Union's Registration, Evaluation, Authorization and Restriction of Chemicals program estimated that 500,000 tons per year (1,000,000,000 lb/yr) of 1,3-butadiene were used at industrial sites for fueling purposes (Penman et al., 2015).

The CDR product category code for fuels and related products includes cooking and heating fuels, fuel additives, and vehicle and appliance fuels. EPA did not identify information on how 1,3-butadiene is used in fuels and related products. One company reporting to CDR indicated that the chemical is used in the aerospace sector, as a fuel binder for solid rocket fuels. NLM's Hazardous Substance Databank (HSDB) (NLM, 2003) confirms that polybutadiene (a polymer formed from the polymerization of 1,3-butadiene) is used as a matrix for rocket propellant as a binder, rather than the 1,3-butadiene monomer itself.

Evidence was found, however, of 1,3-butadiene's presence within butane liquified petroleum gas (LPG) product, which is used as a fuel (Valero, 2018). The SDS for butane LPG states the product "is intended for use as a fuel in devices designed for combustion of butane, or for use in industrial processes," and is a mixture of the chemicals listed in Table 3-36.

Table 3-36. Chemical Makeup of Liquified Petroleum Gas

Chemical Name	CASRN	Percent
n-Butane	106-97-8	0–95
Isobutane	75-28-5	0–95
1,3-Butadiene	106-99-0	0–0.1

This SDS is used as the basis for the assessment of 1,3-butadiene use in fuels.

Liquified petroleum gas can be used for the same domestic, commercial and industrial applications as natural gas, with the largest market for LPG being the domestic/commercial market. Further, one of the main LPG uses is in rural areas for domestic cooking and heating. For commercial and industrial settings, LPG is used as a primary or backup fuel in small boilers and space heating equipment and is used to generate heat and process steam. Pressurized cylinder sizes will vary depending on the application (*i.e.*, larger cylinders would be used for industrial applications versus smaller cylinders for consumer cooking).

Using 2017 NAICS data, LPG is typically manufactured at sites identifying as the following:

- 132199 Natural Gas Liquids;
- 211130 Natural Gas Extraction/Natural Gas Liquids; and
- 324110 Petroleum Refineries.

These producers may use the LPG for heating or steam generation as noted above or sell the LPG to wholesalers and distributers identified within these NAICS categories:

- 221210 Natural Gas Distribution (which includes LPG)

- 424710 Petroleum Bulk Stations and Terminals;
- 424720 Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals); and
- 457210 Fuel Dealers (retail sale of heating oils, LPG, and other fuels via direct sale (home delivery)

Because of LPG uses within commercial, industrial and consumer sectors, specific NAICS codes for downstream use sites cannot be quantified. Further, the consumer use for cooking and heating, paired with the fact that LPG can be used at any industrial or commercial site with equipment compatible to combust LPG, would indicate use at a large number of unknown sites. For these reasons, an accurate number of use site determinations could not be completed.

3.11.2 Release Assessment

When evaluating releases related to fuel use of 1,3-butadiene in LPG, CDR and the SDS for the LPG butane containing 0-0.1 percent 1,3-butadiene were considered. From CDR, the 2019 nationally aggregated PV estimate for butane was 80,000,000,000 to less than 90,000,000,000 lb. To determine the amount of 1,3-butadiene in LPG, the following assumptions were made:

- PV range for butane assumed to be 80 to 90 billion lb;
- 100 percent of the butane PV is used for LPG product;
- 100 percent of the butane PV LPG is used domestically (none is exported);
- The LPG butane product is 99.9 percent butane;
- The concentration of 1,3-butadiene in the LPG butane product is 0.1 percent; and
- All LPG butane product is used domestically (none exported) and used as a fuel.

Taking the above into account, a rough estimate for 1,3-butadiene in the LPG butane product would equal:

$$Amount\ BD = 80{,}000{,}000 - 90{,}000{,}000\ lb\ x\ 0.1\%\ BD$$
$$80{,}000{,}000 - 90{,}000{,}000\ lb\ BD$$

Where:

BD = 1,3-Butadiene
Lb = Pounds

This assumes the amount of the LPG product ranges from 80,080,000,000 to 90,090,000,000 lb.

Limitations and uncertainties associated with the 1,3-butadiene PV estimate include

- It is unlikely the entire PV reported for butane is used in the LPG product.
- It is unlikely none of the reported PV for butane is exported.
- The 1,3-butadiene concentration of 0.1 percent is an overestimate as the SDS states the concentration may range from 0 to 0.1 percent.

Next, potential release sources and estimates were considered. Potential sources of 1,3-butadiene release during LPG fuel use include

- connecting/disconnecting LPG cylinders from combustion equipment;
- container/cylinder leaks and spills; and
- incomplete combustion of LPG fuel.

All releases are expected to air as the LPG is a liquified gas under pressure within pressurized cylinders. Due to the volatility of the components, including 1,3-butadiene, when released from the pressurized container to atmospheric pressure, the LPG volatilizes to a gas.

LPG Connections
Pressurized LPG containers require connections with regulators to reduce the pressure of the cylinder contents before routing to the combustion equipment. Releases are only likely to occur if connection equipment is damaged or worn. Releases from this source are expected to be minimal.

Cylinder Leaks
LPG is sold in various size containers holding 4.5 to over 250 gallons. The amount of LPG in a cylinder and the storage pressure would both be factors to consider when estimating leaks. However, cylinder leaks are not typical. LPG cylinders are designed with a self-closing valve to prevent leaks. Based on the range of cylinder sizes and lack of information on LPG cylinder leaks, releases from this source were not quantified.

Combustion
LPG is highly combustible with a theoretical conversion of 99.5 percent of the fuel carbon converted to CO_2 during combustion. However, some incomplete combustion of the fuel may occur. Conditions that can lead to incomplete combustion, include, but are not limited to

- insufficient oxygen availability;
- extreme excess air levels leading to quenching;
- poor fuel/air mixing;
- cold wall flame quenching;
- reduced combustion temperature;
- decreased combustion gas residence time; and
- reduced combustion intensity.

No estimation method for the level of incomplete combustion was found. However, it is assumed LPG systems are designed to maximize fuel combustion efficiency. For these reasons, it is assumed most 1,3-butadiene in the LPG product would be combusted.

Environmental releases of 1,3-butadiene in LPG used as a fuel could not be quantified based on the following:

- Uncertainty of the amount of 1,3-butadiene in the LPG product;
- Potential dispersed use of the LPG product across domestic, commercial and industrial applications;
- Inability to determine a reasonable number of use sites;
- Projected minimal/unquantifiable environmental releases;
    - From connecting equipment and cylinder leaks; and
    - High combustion efficiency of LPG fuel.

3.11.3 Occupational Exposure Assessment

Potential sources of 1,3-butadiene occupational exposure during LPG fuel use include

- connecting/disconnecting LPG cylinders from combustion equipment;
- spills/leaks from LPG cylinders; and
- 1,3-butadiene released due to incomplete combustion.

LPG Connections
Exposures during connecting/disconnecting cylinders are minimized based on existing LPG cylinder connections. It is also expected that the time spent connecting/disconnecting LPG cylinders is short. Therefore, occupational exposures from routine connecting/disconnecting cylinders are expected to be

minimal.

Cylinder Leaks

The amount spilled/leaked is dependent on the storage pressure and amount of LPG in a cylinder. Further, leaks are uncommon based on cylinder design. Therefore, occupational exposures from cylinder leaks were not quantified.

Incomplete Combustion

While LPG has a high theoretical conversion of over 99 percent, workers may be exposed to 1,3-butadiene during use as a fuel due to incomplete combustion as discussed above. No exposure data or estimation methods for occupational exposure from incomplete combustion were found. Further, workers at industrial and commercial facilities using LPG fuel are not expected to be routinely in proximity of the combustion area; only for short, sporadic time periods. Therefore, it is assumed worker exposure to 1,3-butadiene from incomplete combustion would be minimal.

3.12 Recycling

3.12.1 Process Description

The final scope for 1,3-butadiene lists recycling as an in-scope COU (U.S. EPA, 2020c). 2019 TRI data indicates that sites recycle 1,3-butadiene both on- and off-site (U.S. EPA, 2021b). There are multiple ways 1,3-butadiene can be recycled during its lifecycle. First, when finished 1,3-butadiene does not meet commercial specifications, it is often combined with crude streams for energy recovery. Similarly, when ethylene manufacturers have excess butadiene supply, they can recycle the butadiene as a feedstock for the production of ethylene. In polymer production, unreacted butadiene-containing monomers are recycled back to the reactors to improve the process yield (Sun and Wristers, 2002).

This OES examines releases and exposures due to the to the recycling of 1,3-butadiene for energy recovery. Recycling of butadiene for use in other reactions is handled within Processing as a reactant or the plastic and rubber compounding OES. The term “recycling” within the risk evaluation may also refer to the recycling of plastic and rubber products. For a discussion of this use, see Section 3.5.

3.12.2 Facility Estimates

Between 2016 and 2021, EPA used TRI and NEI to identify 10 facilities that potentially use 1,3-butadiene during recycling.

Facilities that produce or handle 1,3-butadiene may have several uses for the chemical on-site. Despite this, for the purposes of our assessment each site can only be assigned one OES. The OES was chosen using professional judgment to reflect the most prominent activity according to TRI and NEI reporting and the information on the company website. Since deciding the “most prominent activity” is subjective, EPA developed a systematic approach to sorting these release sites in TRI (which was then adapted to NEI). The recycling OES may have been selected if a facility indicated that there was on-site use, or ancillary or other use of 1,3-butadiene coupled with an indication of use as fuel.

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to recycling that reported to CDR, TRI, and/or NEI.

EPA did not identify data on recycling facility operating schedules; therefore, EPA assumes facility operates 7 days/week and 50 weeks/yr (with 2 weeks down for turnaround), which is 350 days per year

of operation (Section 2.3.2).

3.12.3 Release Assessment

3.12.3.1 Environmental Release Points

Sources of potential environmental release include the unloading of solid or liquid waste containers. Releases may also occur while connecting and disconnecting transfer lines and hoses, and during the recycling of 1,3-butadiene for energy recovery. EPA expects releases of 1,3-butadiene to air during recycling, including stack air releases from vented losses to air during process operations and fugitive air releases from leakage of pipes, flanges, and accessories used for transport.

3.12.3.2 Environmental Release Assessment Results

EPA used 2016-2021 TRI, 2017 NEI, and 2020 NEI to estimate environmental releases during the recycling of 1,3-butadiene, as presented in Table 3-37. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, fugitive air, stack air, and land disposal.

Table 3-37. Summary of Environmental Releases in the Recycling of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Surface water	5.2	11	350	1.5E−02	3.1E−02	2	TRI
Fugitive air	20	160		5.8E−02	0.46	9	TRI
Fugitive air	20	183		5.8E−02	1.3E−02	7	NEI
Stack air	13	475		3.6E−02	1.4	11	TRI
Stack air	3.9	459		1.3E−02	1.3	7	NEI
Land	1.6E−04	1.6E−04		4.6E−07	4.6E−07	1	TRI

3.12.4 Occupational Exposure Assessment

3.12.4.1 Worker Activities

EPA expects that the worker exposure activities that occur at a facility that recycles 1,3-butadiene for energy recovery would be similar to the activities at a facility for waste handling, treatment, and disposal of 1,3-butadiene. For more information on expected worker activities see Section 3.13.4.1.

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 than workers that engage in tasks related to the handling or treatment of waste containing 1,3-butadiene.

3.12.4.2 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 1,3-butadiene during recycling (U.S. BLS, 2023). 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 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

Table 3-38 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.12.2.

Table 3-38. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Recycling

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
10	562211 – Hazardous Waste Treatment and Disposal	18	5

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

3.12.4.3 Occupational Inhalation Exposure Results

No discrete monitoring data were found for workers or ONUs during the recycling of 1,3-butadiene. One source was found but lacked critical metadata needed for an occupational exposure assessment. Therefore, EPA used ACC exposure monitoring discussed in Section 3.1.4.3 as analogous for this OES. Specifically, EPA used ACC data associated with waste handling at manufacturing sites because these activities are also expected to occur at recycling sites (ToxStrategies, 2021).

EPA identified 10 task-based worker PBZ samples associated with waste handling from the ACC industrial hygiene report (ToxStrategies, 2021). The worker activities associated with these data include handling facility waste streams containing 1,3-butadiene—including disposing of analytical samples, loading of recycled oil, and operations conducted at the onsite waste-water treatment plant. The sample durations ranged from 15 to 239 minutes. EPA assumes that at a waste facility, the bulk of the day will be spent handling waste such that the task-based samples are representative of a full-shift exposure. EPA did not identify any full-shift ONU PBZ samples during data evaluation.

EPA compiled 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 3-39. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-39. Summary of Inhalation Exposures of Workers to 1,3-Butadiene During Recycling of 1,3-Butadiene, Based on ACC Data

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
Number of Samples	10		0	
8-Hour TWA Exposure Concentrations	1.3	0.23	0.23	0.23
Acute Exposure Concentrations (AC)	0.88	0.16	0.16	0.16
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	0.65	0.11	0.11	0.11
Average Daily Concentration (ADC)	0.63	0.11	0.11	0.11
Lifetime Average Daily Concentration (LADC)	0.16	2.2E−02	2.8E−02	2.2E−02

3.13 Waste Handling, Disposal, and Treatment

3.13.1 Process Description

Each of the conditions of use of 1,3-butadiene may generate waste streams of the chemical that are collected and transported to third-party sites for disposal or treatment. Industrial sites that treat and/or dispose of onsite wastes that they themselves generate are assessed in each condition of use assessment (Sections 3.1 through 3.12). Note, point source discharges are exempt as solid wastes under RCRA. Wastes of 1,3-butadiene that are generated during a condition of use and sent to a third-party site for treatment, disposal, or recycling may include the following:

- Wastewater: 1,3-butadiene may be contained in wastewater discharged to POTW or other, non-public treatment works for treatment. Off-site transfers from plastic compounding and mixing may include aqueous streams that may be collected and destined for off-site treatments. These include particulate matter collected in air pollution control devices, wastewater and slurries from equipment cleaning, plastic pellet spills, and container residue (OECD, 2005). Industrial wastewater containing 1,3-butadiene discharged to a POTW may be subject to EPA or authorized NPDES state pretreatment programs. The assessment of wastewater discharges to POTWs and non-public treatment works of 1,3-butadiene is included in each of the condition of use assessments in Sections 3.1 through 3.12.
- Solid Wastes: Solid wastes are defined under RCRA as any material that is discarded by being: abandoned; inherently waste-like; a discarded military munition; 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. Similar to wastewater streams, off-site transfers from plastic compounding and mixing may include solids that are collected and destined for off-site treatments (OECD, 2005).

- Wastes Exempted as Solid Wastes under RCRA: Certain conditions of use of 1,3-butadiene may generate wastes of 1,3-butadiene that are exempted as solid wastes under 40 CFR 261.4(a). For example, the generation and legitimate reclamation of hazardous secondary materials of 1,3-butadiene may be exempt as a solid waste.

EPA evaluated occupational exposures for disposal. Section 3.13.3 describes the environmental releases related to waste handling, disposal, and treatment, which may lead to exposures of the general population and environmental organisms.

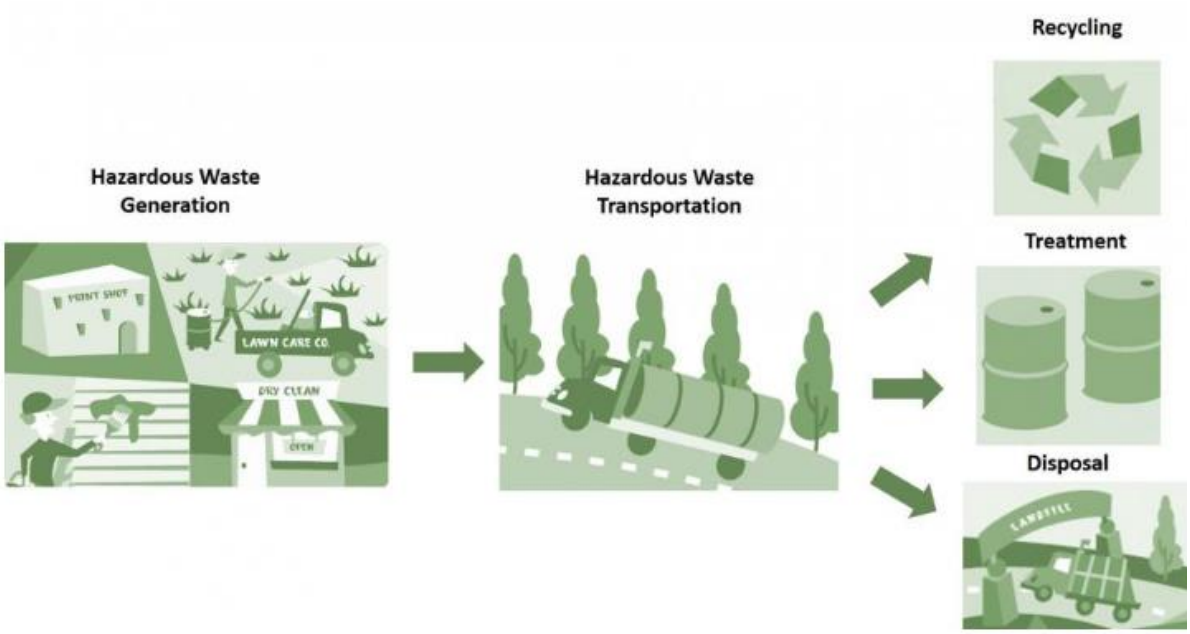


Figure 3-10. Typical Waste Disposal Process
Source: U.S. EPA, 2019a

Municipal Waste Incineration

Municipal waste combustors (MWCs) that recover energy are generally located at large facilities comprising an enclosed tipping floor and a deep waste storage pit. Typical large MWCs may range in capacity from 250 to over 1,000 tons per day. At facilities of this scale, waste materials are not generally handled directly by workers. Trucks may dump the waste directly into the pit, or waste may be tipped to the floor and later pushed into the pit by a worker operating a front-end loader. A large grapple from an overhead crane is used to grab waste from the pit and drop it into a hopper, where hydraulic rams feed the material continuously into the combustion unit at a controlled rate. The crane operator also uses the grapple to mix the waste within the pit, in order to provide a fuel consistent in composition and heating value, and to pick out hazardous or problematic waste.

Facilities burning refuse-derived fuel (RDF) conduct on-site sorting, shredding, and inspection of the waste prior to incineration to recover recyclables and remove hazardous waste or other unwanted materials. Sorting is usually an automated process that uses mechanical separation methods, such as trommel screens, disk screens, and magnetic separators. Once processed, the waste material may be transferred to a storage pit, or it may be conveyed directly to the hopper for combustion.

Tipping floor operations may generate dust. Air from the enclosed tipping floor, however, is continuously drawn into the combustion unit via one or more forced air fans to serve as the primary combustion air and minimize odors. Dust and lint present in the air is typically captured in filters or

other cleaning devices in order to prevent the clogging of steam coils, which are used to heat the combustion air and help dry higher-moisture inputs (Kitto and Stultz, 1992).

Hazardous Waste Incineration

Commercial scale hazardous waste incinerators are generally two-chamber units, a rotary kiln followed by an afterburner, that accept both solid and liquid waste. Liquid wastes are pumped through pipes and are fed to the unit through nozzles that atomize the liquid for optimal combustion. Solids may be fed to the kiln as loose solids gravity fed to a hopper, or in drums or containers using a conveyor (Center, 2018; Heritage, 2018).

Incoming hazardous waste is usually received by truck or rail, and an inspection is required for all waste received. Receiving areas for liquid waste generally consist of a docking area, pumphouse, and storage facilities. For solids, conveyor devices are typically used to transport incoming waste (Center, 2018; Kitto and Stultz, 1992)

Smaller scale units that burn municipal solid waste or hazardous waste (such as infectious and hazardous waste incinerators at hospitals) may require more direct handling of the materials by facility personnel. Units that are batch-loaded require the waste to be placed on the grate prior to operation and may involve manually dumping waste from a container or shoveling waste from a container onto the grate.

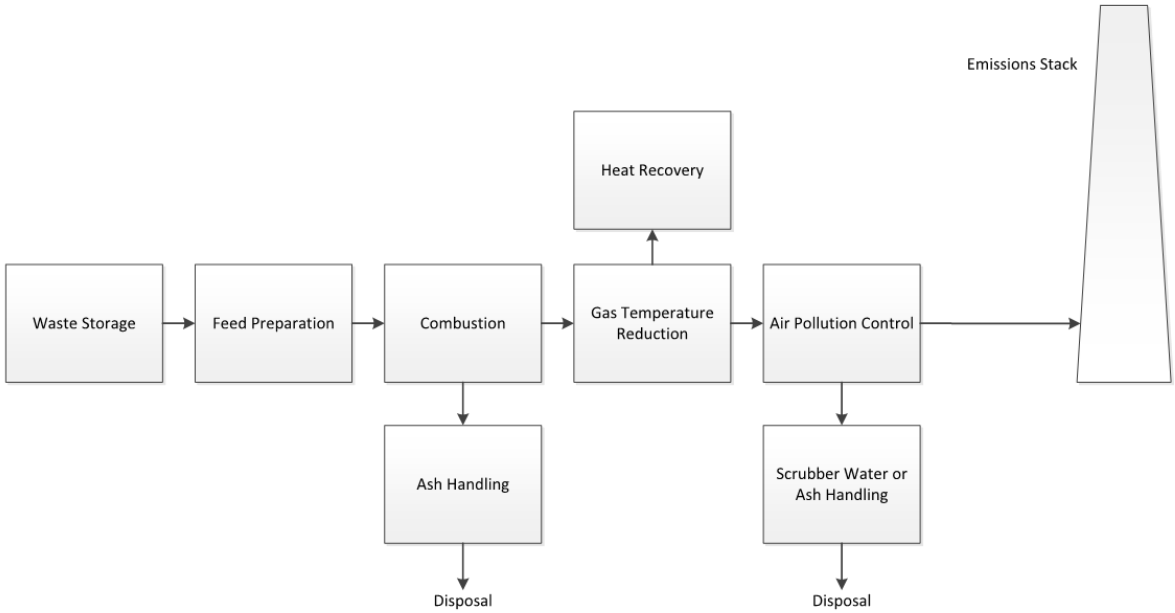


Figure 3-11. Typical Industrial Incineration Process

Municipal Waste Landfill

Municipal solid waste landfills are discrete areas of land or excavated sites that receive household wastes and other types of non-hazardous wastes (*e.g.*, industrial and commercial solid wastes). Standards and requirements for municipal waste landfills include location restrictions, composite liner requirements, leachate collection and removal system, operating practices, groundwater monitoring requirements, closure-and post-closure care requirements, corrective action provisions, and financial assurance. Non-hazardous solid wastes are regulated under RCRA Subtitle D, but states may impose more stringent requirements.

Municipal solid wastes may be first unloaded at waste transfer stations for temporary storage, prior to being transported to the landfill or other treatment or disposal facilities.

Hazardous Waste Landfill

Hazardous waste landfills are excavated or engineered sites specifically designed for the final disposal of non-liquid hazardous wastes. Design standards for these landfills require double liner, double leachate collection and removal systems, leak detection system, run on, runoff and wind dispersal controls, and construction quality assurance program (U.S. EPA, 2018). There are also requirements for closure and post-closure, such as the addition of a final cover over the landfill and continued monitoring and maintenance. These standards and requirements prevent potential contamination of groundwater and nearby surface water resources. Hazardous waste landfills are regulated under CFR Part 264/265, Subpart N.

3.13.2 Facility Estimates

EPA used TRI, NEI, and CDR data between 2016 and 2021 to identify 289 facilities that potentially use 1,3-butadiene during waste handling, treatment, and disposal. Off-site transfers of 1,3-butadiene may go to wastewater treatment, incineration, or recycling facilities; see Figure 3-10. Most off-site transfers for 1,3-butadiene were incinerated. (U.S. EPA, 2021b).

Facilities that produce or handle 1,3-butadiene may have several uses for the chemical on-site. Despite this, for the purposes of our assessment each site can only be assigned one OES. The OES was chosen using professional judgment to reflect the most prominent activity according to TRI and NEI reporting and the information on the company website. Because deciding the "most prominent activity" is subjective, EPA developed a systematic approach to sorting these release sites in TRI (which was then adapted to NEI). The waste handling, disposal, treatment, and recycling OES may have been selected if the facility indicated waste disposal on the company website, or in TRI if a site fell under the NAICS code 562211 (Hazardous Waste Treatment and Disposal).

See *Draft Number of Sites for 1,3-Butadiene* (U.S. EPA, 2024g) for a list of all facilities mapped to waste handling, treatment, and disposal that reported to CDR, TRI, and/or NEI.

EPA did not identify data on facility operating schedules; therefore, EPA assumes operation 5 days/week for 50 weeks/yr, which is 250 days/yr of operation (Section 2.3.2).

3.13.3 Release Assessment

3.13.3.1 Environmental Release Points

Sources of potential environmental release include the unloading of solid or liquid waste containers. Releases may occur while connecting and disconnecting transfer lines and hoses, and during the treatment of waste. EPA expects releases to air of volatile 1,3-butadiene during waste handling, treatment, and disposal. Additionally, the Agency expects releases of solid or liquid waste to land.

3.13.3.2 Environmental Release Assessment Results

EPA used 2016-2021 TRI, 2017 NEI, and 2020 NEI to estimate environmental releases during the waste handling and treatment of 1,3-butadiene, as presented in Table 3-40. According to reported data, 1,3-butadiene is released through the following environmental media: surface water, fugitive air, stack air, and land disposal.

Table 3-40. Summary of Environmental Releases in the Waste Handling, Disposal, and Treatment of 1,3-Butadiene

Environmental Media	Estimated Annual Release Range across Sites (kg/yr)		Number of Release Days	Estimated Daily Release Range across Sites (kg/day)		Number of Facilities	Source(s)
	Central Tendency	High-End		Central Tendency	High-End		
Fugitive air	4.5E−02	3.6	250	1.8E−04	1.4E−02	6	TRI
Fugitive air	0.54	20		1.5E−03	7.8E−02	282	NEI
Stack air	1.7E−01	113		6.9E−04	0.45	6	TRI
Stack air	1.4E−03	0.42		5.4E−06	1.7E−03	282	NEI
Land	5,781	6,226		23	25	2	TRI

3.13.4 Occupational Exposure Assessment

3.13.4.1 Worker Activities

Workers are potentially exposed to 1,3-butadiene via inhalation of vapors 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 1,3-butadiene.

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 than workers that engage in tasks related to the handling or treatment of waste containing 1,3-butadiene.

3.13.4.2 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 1,3-butadiene during waste handling, disposal, and treatment (U.S. BLS, 2023). 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 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

Table 3-41 summarizes the per site estimates for this OES based on the methodology described, including the number of sites identified in Section 3.13.2.

Table 3-41. Estimated Average Number of Workers per Site Potentially Exposed to 1,3-Butadiene During Waste Handling, Disposal, and Treatment

Potential Number of Sites	NAICS Code	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
289	562211 – Hazardous Waste Treatment and Disposal	18	5

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

3.13.4.3 Occupational Inhalation Exposure Results

EPA did not identify monitoring data for the waste handling, treatment, and disposal OES. Therefore, the same approach described in Section 3.12.4.3 for recycling was applied.

EPA compiled 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 3-42. EPA calculated the AC, $ADC_{intermediate}$, ADC, and LADC for ONUs using the central tendency exposure value from worker inhalation estimates.

Table 3-42. Inhalation Exposures of Workers to 1,3-Butadiene During General Waste Handling, Treatment, and Disposal

Exposure Type	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)	
	High-End	Central Tendency	High-End	Central Tendency
8-hour TWA Exposure Concentrations	10		0	
8-hour TWA Exposure Concentrations	1.3	0.23	0.23	0.23
Acute Exposure Concentrations (AC)	0.88	0.16	0.16	0.16
Intermediate Average Daily Concentration ($ADC_{intermediate}$)	0.65	0.11	0.11	0.11
Average Daily Concentration (ADC)	0.63	0.11	0.11	0.11
Lifetime Average Daily Concentration (LADC)	0.16	2.2E−02	2.8E−02	2.2E−02

3.14 Uses Identified During Scoping but Not Assessed

As the risk evaluation process moved past scoping and a deeper understanding of each COU was developed, it was at times determined that a use identified during scoping would not be assessed. In the case of 1,3-butadiene, the following is a list of factors that contributed to these determinations:

1. Lack of reasonably available information: EPA used systematic review to gather reasonably

available information and conducted targeted searches when systematic review left gaps in the Agency's understanding of a given COU. If EPA was unable to find evidence of a use occuring, and further investigation into the rationale for the use's inclusion in the scope did not indicate a true use of the chemical, the Agency decided not to assess the use.

2. Industry comments and outreach: In some cases, EPA received comments or reached out to industry to request further information on certain uses. The industries to reach out to were chosen for a variety of reasons, including if they left a public comment that was relevant to the use in question and EPA needed more clarification, or if it was indicated in a database, company website, or SDSs that a particular entity may have knowledge of the suspected use. These communications sometimes led to the decision to not assess a use in cases where more information from industry indicated that the suspected use is not relevant to the chemical.

3. Increased understanding of 1,3-butadiene's place in the use: Though 1,3-butadiene may have been reported as being present in a particular use, there were cases when it was found upon further investigation that 1,3-butadiene was only present in "up-stream" steps of the processing, and by the time in a product's life cycle it reached the reported COU, 1,3-butadiene was no longer a component, or present only in residual amounts. As detailed in Section 3.3 and Section 3.5, 1,3-butadiene is often reacted to near completion during processing.

The following sections describe each use that was not assessed, and details the specific rationale for why the use was included in the scope but was ultimately excluded from the risk evaluation.

3.14.1 Use of Plastic and Rubber Products

Use of Plastic and Rubber Products

In the final scope for 1,3-butadiene, EPA identifies rubber tires and articles produced with synthetic rubber containing 1,3-butadiene (U.S. EPA, 2020c). It is estimated that more than 3 million metric tons of natural and synthetic rubber are used annually. Half of this use volume is expected to be from the use of styrene-butadiene-rubber (SBR). Half of this SBR is used to make tires (Burgess, 1991). In addition, plastics containing 1,3-butadiene were identified in electronic appliances, furniture and furnishings, toys and recreational products, housewares, packaging, automotive parts, building materials, and 3D-printing filament (Steinle, 2016; Pfäffli and Säämänen, 1993).

As 1,3-butadiene is a building block for many plastics and rubbers, it may be present as a residual within plastic and rubber products. However, the conversion of 1,3-butadiene in these processes is near complete, as discussed in Section 3.3 and Section 3.5. IISRP submitted to EPA the results of a survey conducted in the first quarter of 2020 with manufacturers of synthetic rubber in the United States providing the residual 1,3-butadiene content in their final synthetic rubber product. The highest concentration of the survey was for emulsion styrene butadiene rubber where manufacturers reported less than 50 ppb residual butadiene present in the final product using the method of Head Space-Gas Chromatography / Mass Spectrometry (EPA-HQ-OPPT-2018-0451-0027). In another comment, IISRP informed that a synthetic rubber product produced in Europe may have residual butadiene content of less than 1 ppm (EPA-HQ-OPPT-2018-0451-0003). The highest residual 1,3-butadiene content that EPA found in a plastic or rubber product was 6.6 ppm found in 1,3-butadiene rubber-modified acrylonitrile-acrylic bottles used for olive oil (ATSDR, 2012). The U. S. Tire Manufacturers Association stated in another public comment that 1,3-butadiene cannot be created from the use of synthetic rubber in the manufacture of a tire because once polymerization has occurred it is nearly impossible to break the polymer chain back into individual units of 1,3-butadiene (EPA-HQ-OPPT-2018-0451-0046). Due to this lack of evidence that 1,3-butadiene is present at any higher amounts, EPA did not quantify these releases or exposures.

Recycling of Plastic and Rubber Products

The final scope for 1,3-butadiene lists recycling as an in-scope condition of use (U.S. EPA, 2020c). The recycling of 1,3-butadiene monomer is discussed in Section 3.12. The recycling of plastic and rubber products is sorted under this OES. One example is the recycling of acrylonitrile-butadiene-styrene which is often recovered from waste electrical and electronic equipment (WEEE). Here, the plastic components of the equipment are separated from metals and electronic components. Then, thermoplastics like ABS are commonly recycled via mechanical recycling (injection molding, extrusion, rotational molding and compression molding) into newly shaped products (Suresh et al., 2018). Another example is tire crumbs, specifically the recycling of tires for use on synthetic turf fields (U.S. EPA, 2019c).

In a July 2019 report on synthetic turf field recycled tire crumbs, EPA found that all 1,3-butadiene measurements at recycling plants were below the limit of detection, and on synthetic turf fields, only the 90th percentile of samples was above quantifiable limits, with the maximum measurement being 0.23 ng/g/h (U.S. EPA, 2019c). This along with the fact that finished plastic and rubber products are the items to be recycled in this scenario, the principles of the release and exposure to 1,3-butadiene during the use of plastic and rubber products described above were determined to be applicable to this scenario.

Automotive Care Products

The final scope for 1,3-butadiene lists the commercial use of automotive care products as an in-scope condition of use (U.S. EPA, 2020c). The 2016 CDR data included two submissions from sites that used 1,3-butadiene in automotive care products. Most automotive applications of 1,3-butadiene pertain to tires, tire products, and coatings (Greene and Pennington, 1977). These applications are discussed earlier in this section, as well as Section 3.9.

Due to the fact that these listed products are finished plastic and rubber products, the principles of the release and exposure to 1,3-butadiene during the use of plastic and rubber products described above were determined to be applicable to this scenario.

3.14.2 Use of Lubricants and Greases

1,3-butadiene has been identified in automotive lubricants and aircraft lubricants (OECD, 2020; Envirologic Data, 1992). Specifically, styrene-butadiene copolymers are added to lubricants to act as viscosity modifiers. The copolymers are solids that are incorporated into a liquid lubricant. They reduce the rate of viscosity change with temperature and reduce cold starting effort and oil and fuel consumption. Some products also combine viscosity improvement with pour depressing and/or dispersant properties. These viscosity modifiers are present in lubricants in concentrations of 2 to 15 percent. EPA didn't find any chemical-specific throughputs or use rates for 1,3-butadiene in the use of lubricants and greases.

As described in Section 3.5 which discusses 1,3-butadiene's role in the manufacturing of styrene-butadiene copolymers, the 1,3-butadiene monomer is present at very low levels within the finished styrene-butadiene copolymer product. Further, due to lack of evidence otherwise, it was determined that 1,3-butadiene is not present within lubricants and greases for any purpose other than the amount that may be residual within the styrene-butadiene copolymer. EPA did not find evidence in an SDS or other standard source database that 1,3-butadiene is present in lubricant or grease products.

4 SUMMARY OF ENVIRONMENTAL RELEASE ESTIMATES

In Table 4-1, EPA provides a summary for each OES by indicating the type of release and number of facilities. The table below is a conglomeration of all the tables presented throughout Section 3. EPA provides high-end and central tendency daily as well as yearly release estimates. The relevant supplemental files contain the calculations of the central tendency and high-end annual and daily releases for each OES that used EPA databases to estimate releases. Land release calculations are in *Draft Land Releases for 1,3-Butadiene* (U.S. EPA, 2024f). Water release calculations are in *Draft Water Releases for 1,3-Butadiene* (U.S. EPA, 2024l). Air release calculations using TRI are in *Draft Air Releases (TRI) for 1,3-Butadiene* (U.S. EPA, 2024d). Air release calculations using NEI, all annual and daily calculations from both years (2017 and 2020) are in *Draft Air Releases (NEI2017) for 1,3-Butadiene* (U.S. EPA, 2024b). The raw release data from NEI 2020 are in the *Draft Air Releases (NEI2020) for 1,3-Butadiene* (U.S. EPA, 2024c).

Table 4-1. Summary of Environmental Releases by OES

OES	Estimated Annual Release (kg/site-yr)		Type of Discharge[b], Air Emission[c], or Transfer for Disposal[d]	Estimated Daily Release (kg/site-day) [e]		Number of Facilities	Source(s)
	Central Tendency	High-End[a]		Central Tendency	High-End		
Manufacturing	2.3	371	Surface water	6.5E−03	1.1	4	TRI
	7,500	2.1E04	WWT	22	59	3	TRI
	360	8,419	Fugitive air	1.0	24	37	TRI
	649	7,139	Fugitive air	1.9	20	45	NEI
	1,142	3.3E04	Stack air	3.3	95	39	TRI
	665	1.7E04	Stack air	2.0	46	45	NEI
	0.45	120	Land	1.3E−03	0.34	9	TRI
Repackaging	2.3	4.3	Surface water	6.5E−03	1.2E−02	1	TRI
	18	3,559	Fugitive air	5.1E−02	10	22	TRI
	1.6	999	Fugitive air	4.6E−03	2.8	89	NEI
	21	1,970	Stack air	5.9E−02	5.6	24	TRI
	23	1,127	Stack air	7.4E−02	3.2	89	NEI
	2.3	6.8	Land	6.5E−03	1.9E−02	2	TRI

OES	Estimated Annual Release (kg/site-yr)		Type of Discharge[b], Air Emission[c], or Transfer for Disposal[d]	Estimated Daily Release (kg/site-day) [e]		Number of Facilities	Source(s)
	Central Tendency	High-End[a]		Central Tendency	High-End		
Processing as a reactant	2.3	21	Surface water	6.5E−03	6.0E−02	4	TRI
	1.2	6.3	POTW	3.5E−03	1.8E−02	3	TRI
	0.5	0.5	WWT	1.3E−03	1.3E−03	1	TRI
	64	1,778	Fugitive air	0.18	5.08	54	TRI
	49	2,986	Fugitive air	0.13	8.2	70	NEI
	94	4,419	Stack air	0.27	13	53	TRI
	54	3,632	Stack air	0.15	10	70	NEI
	0.69	207	Land	2.0E−03	0.59	13	TRI
Processing – incorporation into formulation, mixture, or reaction product	7.7	8.8	Surface water	3.1E−02	3.5E−02	2	TRI
	1.4	2.5	POTW	5.4E−03	1.0E−02	2	TRI
	79	120	WWT	0.32	0.48	1	TRI
	10	712	Fugitive air	4.0E−02	2.8	47	TRI
	3.9	282	Fugitive air	1.5E−02	0.89	153	NEI
	56	1,349	Stack air	0.22	5.4	49	TRI
	12	455	Stack air	3.7E−02	1.2	153	NEI
	27	1.0E04	Land	0.11	40	4	TRI
Plastics and rubber compounding	22	51	Surface water	7.5E−02	0.17	4	TRI
	2.3	266	WWT	7.6E−03	0.89	3	TRI
	635	8,385	Fugitive air	2.1	28	31	TRI
	453	8,048	Fugitive air	1.7	22	65	NEI
	903	1.7E04	Stack air	3.0	56	33	TRI
	142	9,294	Stack air	0.43	33	65	NEI
	49	366	Land	0.16	1.2	7	TRI

OES	Estimated Annual Release (kg/site-yr)		Type of Discharge[b], Air Emission[c], or Transfer for Disposal[d]	Estimated Daily Release (kg/site-day) [e]		Number of Facilities	Source(s)
	Central Tendency	High-End[a]		Central Tendency	High-End		
Plastics and rubber converting	113	215	Fugitive air	0.38	0.72	1	TRI
	0.57	18	Fugitive air	1.9E−03	7.3E−02	76	NEI
	113	215	Stack air	0.38	0.72	2	TRI
	6	46	Stack air	1.9E−02	0.14	76	NEI
	113	113	Land	0.38	0.38	1	TRI
Use of laboratory chemicals	6.4E−02	6.3	Fugitive air	2.6E−04	2.5E−02	5	NEI
	37	53	Stack air	0.1	0.14	5	NEI
Application of paints and coatings	0.2	31	Fugitive air	5.7E−04	0.12	28	NEI
	13	370	Stack air	4.4E−02	1.1	28	NEI
Application of adhesives and sealants	108	108	Stack air	0.41	0.43	1	NEI
	19	205	Fugitive or stack air	0.11	1.0	2–299,581 generic sites	Environmental release modeling
	589	2,878	Incineration or landfill	2.7	15		
	2.7E04	1.2E05	Air, incineration, or landfill	124	631		
Recycling	5.2	11	Surface water	1.5E−02	3.1E−02	2	TRI
	20	160	Fugitive air	5.8E−02	0.46	9	TRI
	20	183	Fugitive air	5.8E−02	1.3E−02	7	NEI
	13	475	Stack air	3.6E−02	1.4	11	TRI
	3.9	459	Stack air	1.3E−02	1.3	7	NEI
	1.6E−04	1.6E−04	Land	4.6E−07	4.6E−07	1	TRI
Waste handling, disposal, and treatment	4.5E−02	3.6	Fugitive air	1.8E−04	1.4E−02	6	TRI
	0.54	20	Fugitive air	1.5E−03	7.8E−02	282	NEI
	1.7E−01	113	Stack air	6.9E−04	0.45	6	TRI
	1.4E−03	0.42	Stack air	5.4E−06	1.7E−03	282	NEI
	5,781	6,226	Land	23	25	2	TRI
Distribution in commerce	N/A[f]						

OES	Estimated Annual Release (kg/site-yr)		Type of Discharge[b], Air Emission[c], or Transfer for Disposal[d]	Estimated Daily Release (kg/site-day) [e]		Number of Facilities	Source(s)
	Central Tendency	High-End[a]		Central Tendency	High-End		

[a] "High-End" are defined as 95th percentile releases.
[b] Direct discharge to surface water and indirect discharges to WWT or POTW are included.
[c] Emissions via fugitive air; stack air; or treatment via incineration
[d] Transfer to surface impoundment, land application, or landfills
[e] Where available, EPA used peer-reviewed literature (*e.g.*, GSs or ESDs) to provide a basis to estimate the number of release days of 1,3-butdiene within an OES.
[f] While EPA considers distribution of commerce activities such as loading and unloading as part of each uses' OES, EPA also reviewed NRC data (NRCe, 2009) and DOT data (U.S. Department of Transportation, 2024) for the 2016–2021 calendar years for incident reports pertaining to distribution of 1,3-butadiene. Discussion and results on this topic are in Section 3.7.

3425

5 SUMMARY OF OCCUPATIONAL EXPOSURE ESTIMATES

Table 5-1 summarizes the occupational inhalation exposure results for each OES. EPA's general approach for estimating occupational exposures is explained in Section 2.4 and the specific basis for each estimate is discussed in the relevant subsection of Section 3. See the "Inhalation Data" tab in the *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2024i) for the calculations for this table.

Table 5-1 Summary of Occupational Inhalation Exposure Results by OES

OES	Worker Description	Exposure Days (day/yr)	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)		Sources/Notes
			High-End	Central Tendency	High-End	Central Tendency	
Manufacturing	Infrastructure/ distribution operations	250	0.45	2.5E−02	1.7E−02	8.0E−03	ToxStrategies (2021) data for manufacturing and processing facilities
	Instrument and electrical	250	0.16	2.0E−02			
	Laboratory technician	250	0.24	2.5E−02			
	Machinery and specialists' group	250	0.28	6.0E−03			
	Maintenance technician	250	0.23	0.15			
	Operations onsite	250	0.2	2.0E−02			
	Safety, health, and engineering	250	0.36	3.8E−02			
Processing – repackaging	–	26–128	15	1.1	1.1		Used analogous data from loading/unloading during manufacturing and processing. ONU data not available; used the central tendency from worker estimates.

OES	Worker Description	Exposure Days (day/yr)	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)		Sources/Notes
			High-End	Central Tendency	High-End	Central Tendency	
Processing as a reactant	Infrastructure/ distribution operations	250	0.45	2.5E−02	1.7E−02	8.0E−03	ToxStrategies (2021) data for manufacturing and processing facilities
	Instrument and electrical	250	0.16	2.0E−02			
	Laboratory technician	250	0.24	2.5E−02			
	Machinery and specialists' group	250	0.28	6.0E−03			
	Maintenance technician	250	0.23	0.15			
	Operations onsite	250	0.2	2.0E−02			
	Safety, health, and engineering	250	0.36	3.8E−02			
Processing – incorporation into formulation, mixture, or reaction product	Infrastructure/ distribution operations	250	0.45	2.5E−02	1.7E−02	8.0E−03	ToxStrategies (2021) data for manufacturing and processing facilities
	Instrument and electrical	250	0.16	2.0E−02			
	Laboratory technician	250	0.24	2.5E−02			
	Machinery and specialists' group	250	0.28	6.0E−03			
	Maintenance technician	250	0.23	0.15			
	Operations onsite	250	0.2	2.0E−02			
	Safety, health, and engineering	250	0.36	3.8E−02			
Plastics and rubber compounding	–	250	0.3	3.0E−02	3.0E−02		Based on NIOSH/OSHA data. ONU data not available; used the central tendency from worker estimates.
Plastics and rubber converting	–	250	0.3	2.0E−02	2.0E−02		Based on NIOSH/OSHA data.
Use of laboratory chemicals	Laboratory technician	174 – 250	9.0E−02	6.0E−02	1.7E−02	8.0E−03	Used analogous data from

OES	Worker Description	Exposure Days (day/yr)	Worker Inhalation Estimates (ppm)		ONU Inhalation Estimates (ppm)		Sources/Notes
			High-End	Central Tendency	High-End	Central Tendency	
							manufacturing/processing (laboratory technicians).
Application of paints, coatings, adhesives, and sealants	–	250	9.0E−02	5.0E−02	5.0E−02		Based on NIOSH/OSHA data. All values were below the LOD. Used LOD for the HE and LOD/2 for CT. ONU data not available; used the central tendency from worker estimates.
Recycling	–	250	1.3	0.23	0.23		Used analogous data from waste handling activities during manufacturing / processing. ONU data not available; used the central tendency from worker estimates.
Waste handling, treatment, and disposal	–	250	1.3	0.23	0.23		Used analogous data from waste handling activities during manufacturing / processing. ONU data not available; used the central tendency from worker estimates.

3434

6 WEIGHT OF SCIENTIFIC EVIDENCE CONCLUSIONS FOR ENVIRONMENTAL RELEASES AND OCCUPATIONAL EXPOSURES

For each OES, EPA considered the assessment approach, the quality of the data and models, and the strengths, limitations, assumptions, and key sources of uncertainties in the assessment results to determine a weight of scientific evidence (WOSE) rating. EPA considered factors that increase or decrease the strength of the evidence supporting the release estimate—including quality of the data/information, applicability of the release or exposure data to the OES (including considerations of temporal relevance, locational relevance) and the representativeness of the estimate for the whole industry. The best professional judgment is summarized using the descriptors of robust, moderate, slight, or indeterminant, according to EPA's *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called the "EPA's Draft Systematic Review Protocol") (U.S. EPA, 2021a). For example, a conclusion of moderate is appropriate where there is 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. A conclusion of slight is appropriate where there is limited information that does not sufficiently cover all sites within the OES, and the assumptions and uncertainties are not fully known or documented. See EPA's Draft Systematic Review Protocol (U.S. EPA, 2021a) for additional information on weight of scientific evidence conclusions.

WOSE ratings for the environmental release and 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.

6.1 Environmental Releases

EPA estimated air, water, and land releases of 1,3-butadiene using various methods and information sources, including TRI and NEI data, as well as ESD modeling with Monte Carlo. TRI was determined to have an overall data quality rating of high through EPA's systematic review process, and NEI was determined to have a medium quality rating. EPA determined that the ESD used in the evaluation had an overall data quality rating of high.

Strengths

TRI (which reports releases to air, land, and water) and NEI (which reports releases to air) provided a comprehensive amount of release data for 1,3-butadiene. A strength of using TRI is that it compiles the best readily available release data for all facilities that reported to EPA. For air releases, NEI data captures additional sources that are not included in TRI due to reporting thresholds. Additionally, point sources in NEI report at the emission-unit level.

Although 1,3-butadiene monitoring data are preferred to modeled data, in the case when modeling was needed to estimate releases, EPA strengthened model estimates by using Monte Carlo modeling to allow for variation in environmental release calculation input parameters according to the ESD and other literature sources.

Limitations

When using TRI data to analyze chemical releases, it is important to acknowledge that TRI reporting does not include all releases of the chemical and therefore, the number of sites for a given OES may be underestimated. For each OES that had TRI or NEI data, the analysis of releases for those OESs was

limited to the facilities that reported releases to TRI or NEI. Therefore, it is uncertain the extent to which sites not captured in these databases have air, water, or land releases of 1,3-butadiene.

EPA was unable to map certain facilities in NEI to an OES due to the lack of information regarding the activity of 1,3-butadiene at the site. Therefore, some facilities are mapped to an "Unknown" OES.

For the modeled release, the primary limitation of EPA's approach is the uncertainty in the representativeness of release estimates toward the true distribution of potential releases. In addition, EPA lacks facility PV data, and there are uncertainties in the representativeness of the industry-provided data as well as the operating parameters used in the ESD.

Assumptions

To assess daily air and water discharges, EPA assumed that the number of facility operating days was equal to the number of release days. The Agency has developed generic estimates of operating days for each OES, as described in Section 2.3.2. For the Commercial use of laboratory chemicals OES, EPA assumed the number of operating days based on the Draft GS on Use of Laboratory Chemicals.

There is uncertainty that all sites for a given OES operate for the assumed duration; therefore, the average daily releases may be higher if sites have fewer release days or lower if they have greater release days. Furthermore, 1,3-butadiene concentrations in air emissions and wastewater release to receiving waterbodies at each facility may vary from day-to-day such that on any given day the actual daily releases may be higher or lower than the estimated average daily discharge. Thus, this approach minimizes variations in emissions and discharges from day to day. EPA did not estimate daily land releases due to the high level of uncertainty in the number of release days associated with land releases. The Agency expects that sites may not send waste to landfills every day and are more likely to accumulate waste for periodic shipments to landfills. However, sites that release to municipal landfills may have more frequent release days based on the frequency of shipments.

Uncertainties

Uncertainties with using TRI and NEI data include underestimation of the number of sites for a given OES due to reporting thresholds in TRI, the accuracy of EPA's mapping of sites reporting to TRI and NEI to a specific OES, and quality of the data reported to TRI and NEI.

Some uncertainties of using NEI data include the accuracy of EPA's mapping of sites reporting to NEI to a specific OES. For point sources, there may be multiple feasible OESs at a single facility. Additionally, there is uncertainty due to the voluntary reporting of HAP data. As a result, EPA augments SLT-provided HAP data with other information to better estimate point source HAP emissions. NEI does not require stack testing or continuous emissions monitoring, and reporting agencies may use a number of different emission estimation methods with varying degrees of reliability. These methodologies include continuous emissions monitoring, stack testing, site- and vendor-specific emission factors, SLT and/or other emission factors, and engineering judgement.

One uncertainty for using GS is the lack of specific 1,3-butadiene data. Because GSs are generic, assessed parameter values may not always be representative of applications specific to 1,3-butadiene use in each OES. Another uncertainty is lack of consideration for release controls. The GS assume that all activities occur without any release controls, and in an open-system environment where vapor freely escape (OECD, 2013). Actual releases may be less than estimated if facilities utilize pollution control methods.

In some cases, the number of facilities for a given OES was estimated using data from the U.S. Census. In such cases, the average daily release calculated from sites reporting to TRI or NEI was applied to the total number of sites reported (U.S. BLS, 2023). It is uncertain how accurate this average release is to actual releases at these sites; therefore, releases may be higher or lower than the calculated amount.

Table 6-1 provides a summary of EPA's overall confidence in the environmental release estimates for each OES.

Table 6-1. Summary of Assumptions, Uncertainty, and Overall Confidence in Release Estimates by OES

OES[a]	Weight of Scientific Evidence Conclusion in Release Estimates
Manufacturing	For this OES, EPA had release information for water, land, and air from TRI and for air from NEI. Water releases are assessed using reported releases from the 2016–2021 TRI, which has a high data quality rating from the systematic review process. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. The primary limitation is that the water release assessment is based on seven reporting sites, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 56 additional manufacturing sites that report releases to other media but do not report releases to water. Air releases are assessed using reported releases from 2016–2021 TRI, and 2017 and 2020 NEI, which has a medium data quality rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Land releases are assessed using reported releases from 2016–2021 TRI. The primary limitation is that the land releases assessment is based on four reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 59 additional manufacturing sites that report releases to other media but do not report releases to land. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Repackaging	For this OES, EPA had release information for water, land, and air from TRI and for air from NEI. Water releases are assessed using reported releases from the 2016–2021 TRI, which has a high data quality rating from the systematic review process. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. The primary limitation is that the water release assessment is based on one reporting site, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 114 additional repackaging sites that report releases to other media but do not report releases to water. Air releases are assessed using reported releases from 2016–2021 TRI, and 2017 and 2020 NEI, which has a medium data quality rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Land releases are assessed using reported releases from 2016–2021 TRI. The primary limitation is that the land releases assessment is

OES[a]	Weight of Scientific Evidence Conclusion in Release Estimates
	based on two reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 113 additional manufacturing sites that report releases to other media but do not report releases to land. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Processing as a reactant	For this OES, EPA had release information for water, land, and air from TRI and for air from NEI. Water releases are assessed using reported releases from the 2016–2021 TRI, which has a high data quality rating from the systematic review process. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. The primary limitation is that the water release assessment is based on nine reporting sites, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 94 additional processing as a reactant sites that report releases to other media but do not report releases to water. Air releases are assessed using reported releases from 2016–2021 TRI, and 2017 and 2020 NEI, which has a medium data quality rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Land releases are assessed using reported releases from 2016–2021 TRI. The primary limitation is that the land releases assessment is based on 13 reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 90 additional processing as a reactant sites that report releases to other media but do not report releases to land. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Processing – incorporation into formulation, mixture, or reaction product	For this OES, EPA had release information for water, land, and air from TRI and for air from NEI. Water releases are assessed using reported releases from the 2016–2021 TRI, which has a high data quality rating from the systematic review process. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. The primary limitation is that the water release assessment is based on four reporting sites, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 174 additional sites that report releases to other media but do not report releases to water. Air releases are assessed using reported releases from 2016–2021 TRI, and 2017 and 2020 NEI, which has a medium data quality rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI

OES[a]	Weight of Scientific Evidence Conclusion in Release Estimates
	due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Land releases are assessed using reported releases from 2016–2021 TRI. The primary limitation is that the land releases assessment is based on eight reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 170 additional sites that report releases to other media but do not report releases to land. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Plastics and rubber compounding	For this OES, EPA had release information for water, land, and air from TRI and for air from NEI. Water releases are assessed using reported releases from the 2016–2021 TRI, which has a high data quality rating from the systematic review process. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. The primary limitation is that the water release assessment is based on seven reporting sites, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 66 additional manufacturing sites that report releases to other media but do not report releases to water. Air releases are assessed using reported releases from 2016–2021 TRI, and 2017 and 2020 NEI, which has a medium data quality rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Land releases are assessed using reported releases from 2016–2021 TRI. The primary limitation is that the land releases assessment is based on eight reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 65 additional sites that report releases to other media but do not report releases to land. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Plastics and rubber converting	For this OES, EPA had release information for land and air from TRI and for air from NEI. There were no reported water releases in TRI for this OES. Based on other reporting databases (CDR, NEI, etc.), there are 77 additional sites that report releases to other media but do not report releases to water. Air releases are assessed using reported releases from 2016–2021 TRI, and 2017 and 2020 NEI, which has a medium data quality

OES[a]	Weight of Scientific Evidence Conclusion in Release Estimates
	rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Land releases are assessed using reported releases from 2016–2021 TRI. The primary limitation is that the land releases assessment is based on one reporting site, and EPA did not have additional sources to estimate land releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 76 additional sites that report releases to other media but do not report releases to land. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Use of laboratory chemicals	For this OES, EPA had release information for air from NEI. There were no reported air, water, or land releases in TRI for this OES. Based on other reporting databases (CDR, NEI, etc.), there are five additional sites that report releases to air but do not report releases to water or land. Air releases are assessed using reported releases from 2017 and 2020 NEI, which has a medium data quality rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Application of paints and coatings	For this OES, EPA had release information for air from NEI. There were no reported air, water, or land releases in TRI for this OES. Based on other reporting databases (CDR, NEI, etc.), there are 28 additional sites that report releases to air but do not report releases to water or land. Air releases are assessed using 2017 and 2020 NEI, which has a medium data quality rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.

OES[a]	Weight of Scientific Evidence Conclusion in Release Estimates
Application of adhesives and sealants	EPA identified one facility in NEI reporting air releases of 1,3-butadiene. EPA determined this data is not sufficient to capture the entirety of environmental releases for this scenario. Therefore, releases to the environment are assessed using the ESD on the Industrial Use of Adhesives for Substrate Bonding (OECD, 2013). This ESD has a high data quality rating from the systematic review process. EPA used this ESD combined with Monte Carlo modeling to estimate releases to the environment, with media of release assessed using assumptions from the ESD model. More information about the details and assumptions of the model can be found in Appendix D. EPA believes a strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential releases values is more likely than a discrete value to capture actual releases at sites. EPA believes the primary limitation to be the uncertainty in the representativeness of values toward the true distribution of potential releases. In addition, EPA lacks 1,3-butadiene chemical throughput data and number of facilities; therefore, number of facilities and throughput estimates are based on stock throughputs provided by the ESD and applying conservative assumptions to public comments provided to EPA (see Section 3.10.2). Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Recycling	For this OES, EPA had release information for water, land, and air from TRI and for air from NEI. Water releases are assessed using reported releases from the 2016–2021 TRI, which has a high data quality rating from the systematic review process. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. The primary limitation is that the water release assessment is based on zero reporting sites, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are ten additional sites that report releases to other media but do not report releases to water. Air releases are assessed using reported releases from 2016–2021 TRI, and 2017 and 2020 NEI, which has a medium data quality rating from the systematic review process. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Land releases are assessed using reported releases from 2016–2021 TRI. The primary limitation is that the land releases assessment is based on zero reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are ten additional sites that report releases to other media but do not report releases to land. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
Waste handling,	For this OES, EPA had release information for land and air from TRI and for air from NEI.

OES[a]	Weight of Scientific Evidence Conclusion in Release Estimates
disposal, and treatment	There were no reported water releases in TRI for this OES. Based on other reporting databases (CDR, NEI, etc.), there are 289 additional sites that report releases to other media but do not report releases to water. Air releases are assessed using reported releases from 2016–2021 TRI, and 2017 and 2020 NEI. A strength of NEI data is that NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. Additionally, EPA made assumptions on the number of operating days to estimate daily releases. Land releases are assessed using reported releases from 2016–2021 TRI. The primary limitation is that the land releases assessment is based on two reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on other reporting databases (CDR, NEI, etc.), there are 287 additional sites that report releases to other media but do not report releases to land. Based on this information, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of releases in consideration of the strengths and limitations of reasonably available data.
[a] OESs for Distribution in commerce, Use in fuels and related products, Use of plastic and rubber products, and Use of lubricants and greases are not present in this table because they were not quantitatively assessed.	

3538

6.2 Occupational Exposure

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 EPA by ACC (ToxStrategies, 2021). 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 1,3-butadiene, 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 1,3-butadiene. Manufacturers and importers are only required to report if they manufactured or imported 1,3-butadiene in excess of 25,000 lb at a single site during any calendar year; as such, CDR may not capture all sites and workers.

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 and Wage Statistics program's 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 1,3-butadiene 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 1,3-butadiene 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 EPA's understanding of how 1,3-butadiene 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 industries/occupations with greater exposures might erroneously be excluded. This would result in inaccuracy but would be unlikely to systematically overestimate or underestimate the number of exposed workers.

Analysis of Exposure Monitoring Data

For several OESs, measurement studies of 1,3-butadiene exposure were directly applicable and used to estimate inhalation exposures. The primary strength of these data is the use of personal and applicable data. The primary limitation is that EPA assumed 250 exposure days per year based on 1,3-butadiene exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures.

For the remaining OESs, segments of the monitoring data from the OESs mentioned above were used as analog. 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 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. 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 1,3-butadiene air concentrations and the variability of work practices among different sites.

This report uses existing worker exposure monitoring data to assess exposure to 1,3-butadiene during several conditions of use. To analyze the exposure data, EPA categorized each data point as either "worker" or "occupational non-user." The categorizations are based on descriptions of worker job activity as provided in literature and EPA's professional judgment. In general, samples for employees that are expected to have the highest exposure from direct handling of 1,3-butadiene are categorized as "worker" and samples for employees that are expected to have the lower exposure and do not directly handle 1,3-butadiene are categorized as ONU.

Table 6-2 provides a summary of EPA's overall confidence in its inhalation exposure estimates for each OES.

3607 **Table 6-2. Summary of Assumptions, Uncertainty, and Overall Confidence in Inhalation Exposure Estimates by OES**

OES[a]	Weight of Scientific Evidence Conclusion in Exposure Estimates
Manufacturing	For this OES, EPA had monitoring data from manufacturing and processing facilities. 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 full-shift TWA inhalation exposure estimates for the Manufacturing OES. The primary strength is the use of directly applicable monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ToxStrategies, 2021). Another strength is that the data used from ACC were 1,3-butadiene specific from multiple facilities that manufacture 1,3-butadiene. The primary limitations of these data include the uncertainty as to whether the measured concentrations and exposure frequencies from ACC sites accurately represent the entire industry and the true distribution of inhalation concentrations in this scenario, that the data come from one industry source, and that much of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 250 exposure days per year for 8-hour TWAs and 167 days per year for 12-hour TWAs based on 1,3-butadiene 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 is moderate to robust and provides a plausible estimate of exposures.
Repackaging	For this OES, EPA used analogous data from loading/unloading during manufacturing and processing. ONU data was not available so EPA used the central tendency from worker estimates. 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 full-shift TWA inhalation exposure estimates for the repackaging OES. The primary strength is the use of directly applicable monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ToxStrategies, 2021). The primary limitations of these data include the uncertainty as to whether the analogous data from unloading and loading during manufacturing is representative of the repackaging OES. In addition, there is uncertainty that the measured concentrations from ACC sites accurately represent the entire industry and the true distribution of inhalation concentrations in this scenario, that the data come from one industry source, and that much of the data for workers from the source were reported as below the LOD. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides a plausible estimate of exposures.
Processing as a reactant	For this OES, EPA had monitoring data from manufacturing and processing facilities.

OES[a]	Weight of Scientific Evidence Conclusion in Exposure Estimates
	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 full-shift TWA inhalation exposure estimates for the Processing as a reactant OES. The primary strength is the use of directly applicable monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ToxStrategies, 2021). Another strength is that the ACC data are 1,3-butadiene specific from multiple facilities that process 1,3-butadiene as a reactant. The primary limitations of these data include the uncertainty as to whether the measured concentrations and exposure frequencies from ACC sites accurately represent the entire industry and the true distribution of inhalation concentrations in this scenario, that the data come from one industry source, and that much of the data for both workers and ONUs from the source were reported as below the LOD. Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust and provides a plausible estimate of exposures.
Processing – incorporation into formulation, mixture, or reactant product	For this OES, EPA had monitoring data from manufacturing and processing facilities. 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 full-shift TWA inhalation exposure estimates for the Processing – incorporation into formulation, mixture, or reaction product OES. The primary strength is the use of directly applicable monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ToxStrategies, 2021). Another strength is that the ACC data are 1,3-butadiene specific from multiple facilities that formulate products containing 1,3-butadiene. The primary limitations of these data include the uncertainty as to whether the measured concentrations from ACC sites accurately represent the entire industry and the true distribution of inhalation concentrations in this scenario, that the data come from one industry source, and that much of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 250 exposure days per year based on 1,3-butadiene 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 is moderate to robust and provides a plausible estimate of exposures.
Plastics and rubber compounding	For this OES, EPA had NIOSH/OSHA data and incorporated analogous data from plastics and rubber converting. ONU data was not available, so EPA used the central tendency from worker estimates. EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of

OES[a]	Weight of Scientific Evidence Conclusion in Exposure Estimates
	scientific evidence conclusion for the exposure estimates. EPA used inhalation data to assess inhalation exposures. The primary strength of the data is the use of PBZ monitoring data, which is preferrable to other assessment approaches such as modeling or the use of OELs. In addition, the sampling data was from multiple sites involved in plastics converting. The primary limitation is that a bulk of the data is analogous from plastics and rubber converting. There is uncertainty in the representativeness of this data toward the true distribution of inhalation concentrations in this scenario. EPA also assumed 250 exposure days per year for 8-hour TWAs and 167 days per year for 12-hour TWAs based on 1,3-butadiene 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 is moderate and provides a plausible estimate of exposures.
Plastics and Rubber Converting	For this OES, EPA had NIOSH/OSHA data. 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 exposure estimates. EPA used inhalation data to assess inhalation exposures. The primary strength of the data is the use of personal and directly applicable data. In addition, the sampling data was from multiple sites involved in plastics converting. Systematic review rated two of the three studies used as high quality, and the third as medium quality. The primary limitation is that EPA assumed 250 exposure days per year 8-hour TWAs and 167 days per year for 12-hour TWAs based on 1,3-butadiene 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 is moderate to robust and provides a plausible estimate of exposures.
Use of Laboratory Chemical	For this OES, EPA used comparable analogous monitoring data from manufacturing and processing facilities, specifically those data points from laboratory technicians. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ToxStrategies, 2021). Another strength is that the ACC data are from multiple facilities that handle 1,3-butadiene. The primary limitations to these data include the uncertainty of the representativeness of the exposures for laboratory technicians at manufacturing sites towards workers at commercial laboratories, uncertainty in the representativeness of the data towards the true distribution of inhalation concentrations in this scenario, that the data come from one industry source, and that between 70 and 75 percent of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 250 exposure

OES[a]	Weight of Scientific Evidence Conclusion in Exposure Estimates
	days per year for 8-hour TWAs and 167 days per year for 12-hour TWAs based on 1,3-butadiene 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 is moderate and provides a plausible estimate of exposures in consideration of the strengths and limitations of reasonably available data.
Application of paints and coatings	For this OES, EPA had NIOSH/OSHA data. However, all values were below the LOD. EPA used LOD for the high-end and LOD/2 for central tendency. ONU data were not available thus EPA used the central tendency from worker estimates. 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 exposure estimates. EPA used inhalation data to assess inhalation exposures. The primary strength of the data is the use of personal monitoring data, which is preferrable to other assessment approaches such as modeling or the use of OELs. In addition, the sampling data spanned multiple facilities. The primary limitation is that the data was below the limit of detection. There is uncertainty in the representativeness of this data toward the true distribution of inhalation concentrations in this scenario, since OSHA CEHD does not provide worker activity descriptions. EPA also assumed 260 exposure days per year based on 1,3-butadiene 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 is slight to moderate and provides a plausible estimate of exposures.
Application of adhesives and sealant	For this OES, EPA had NIOSH/OSHA data. However, all values were below the LOD. EPA used LOD for the high-end and LOD/2 for central tendency. ONU data were not available thus EPA used the central tendency from worker estimates. 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 exposure estimates. EPA used inhalation data to assess inhalation exposures. The primary strength of the data is the use of personal and potentially applicable data. The primary limitation is that the data points were all below the limit of detection. There is uncertainty in the representativeness of this data toward the true distribution of inhalation concentrations in this scenario, since OSHA CEHD does not provide worker activity descriptions. EPA also assumed 260 exposure days per year based on 1,3-butadiene 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 is slight to moderate and provides a plausible estimate of exposures.
Recycling	For this OES, EPA used comparable analogous monitoring data from waste handling activities during manufacturing and processing. ONU data were not available, thus EPA used the central tendency from worker estimates.

OES[a]	Weight of Scientific Evidence Conclusion in Exposure Estimates
	The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ToxStrategies, 2021). Another strength is that the ACC data are from multiple facilities that handle 1,3-butadiene. The primary limitations to these data include the uncertainty of the representativeness of the exposures for waste handling at manufacturing sites towards workers at recycling facilities, uncertainty in the representativeness of the data towards the true distribution of inhalation concentrations in this scenario, that the data come from one industry source, and that much of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 250 exposure days per year based on 1,3-butadiene 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 is moderate and provides a plausible estimate of exposures in consideration of the strengths and limitations of reasonably available data.
Waste handling, disposal, and treatment	For this OES, EPA used comparable analogous monitoring data from waste handling activities during manufacturing and processing. ONU data were not available, thus EPA used the central tendency from worker estimates. The primary strength is the use of monitoring data, which are preferrable to other assessment approaches such as modeling or the use of OELs. EPA used PBZ air concentration data to assess inhalation exposures, with the data source having a high data quality rating from the systematic review process (ToxStrategies, 2021). Another strength is that the ACC data are from multiple facilities that handle 1,3-butadiene. The primary limitations to these data include the uncertainty of the representativeness of the exposures for waste handling at manufacturing sites towards workers at waste handling facilities, uncertainty in the representativeness of the data towards the true distribution of inhalation concentrations in this scenario, that the data come from one industry source, and that much of the data for both workers and ONUs from the source were reported as below the LOD. EPA also assumed 250 exposure days per year based on 1,3-butadiene 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 is moderate and provides a plausible estimate of exposures in consideration of the strengths and limitations of reasonably available data.
[a] OES for Distribution in commerce, Use in fuels and related products, Use of plastic and rubber products, and Use of lubricants and greases are not present in this table because they were not quantitatively assessed.	

3608

7 CONCLUSIONS

EPA considered all reasonably available information identified by the Agency through its systematic review process under TSCA (U.S. EPA, 2024k) to characterize the environmental release and occupational exposure of 1,3-butadiene. 1,3-Butadiene has a total PV in the United States between 1 and 5 billion lb from the 2020 CDR reporting period (U.S. EPA, 2020b) and is primarily used as a monomer in the production of a wide range of polymers and copolymers. It is also used as an intermediate in the production of several chemicals.

EPA evaluated environmental releases and occupational exposures for each OES, which are developed based on a set of occupational activities and conditions such that similar occupational exposures and environmental releases are expected from the use(s) covered under each OES. The Agency provided environmental release and 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 release data from the TRI and NEI databases to assess releases to air, land, and water for a majority of 1,3-butadiene uses. One exception was the release from the use of adhesives and sealants, for which modeling approaches were used.

The OESs with the highest expected releases were Manufacturing, Plastic and rubber compounding, and Application of adhesives and sealants. EPA used inhalation monitoring data to evaluate acute, intermediate, and chronic exposures to workers and ONUs for each OES. Where no monitoring data existed relevant to certain OESs, analogous monitoring data were used. Inhalation exposures to 1,3-butadiene from most industrial and commercial OESs are expected to be rather low, with the exception of repackaging.

REFERENCES

ACA (American Coatings Association). (2019). Comment submitted by Raleigh Davis, Assistant Director and Riaz Zaman, Counsel, Government Affairs, American Coatings Association (ACA) regarding the proposed 20 high priority candidates for chemical risk evaluation. Available online at https://www.regulations.gov/comment/EPA-HQ-OPPT-2018-0438-0004

Anderson, D; Hughes, JA; Brinkworth, MH; Peltonen, K; Sorsa, M. (1996). Levels of ras oncoproteins in human plasma from 1,3-butadiene-exposed workers and controls. Mutat Res 349: 115-120. http://dx.doi.org/10.1016/0027-5107(95)00167-0

Arnold, F; Engel, AJ. (2001). Evaporation of pure liquids from open surfaces. In JBHJ Linders (Ed.), Modelling of Environmental Chemical Exposure and Risk (pp. 61-71). The Netherlands: Kluwer Academic Publishers. http://dx.doi.org/10.1007/978-94-010-0884-6_6

ATSDR (Agency for Toxic Substances and Disease Registry). (2012). Toxicological profile for 1,3-butadiene [ATSDR Tox Profile]. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=459&tid=81

Burgess, WA. (1991). Potential exposures in the manufacturing industry—Their recognition and control. In GD Clayton; FE Clayton (Eds.), Patty's industrial hygiene and toxicology, vol 1, pt A General principles (4th ed., pp. 595-674). New York, NY: John Wiley and Sons. http://dx.doi.org/10.1002/0471435139.hyg028

CEB (Chemical Engineering Branch). (1991). Chemical Engineering Branch manual for the preparation of engineering assessments: Volume I. CEB engineering manual. Washington, DC: Office of Pollution Prevention and Toxics, US Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P10000VS.txt

Center, ETCHWR. (2018). High Temperature Incineration. Washington D.C.: Environmental Technology Council Hazardous Waste Resources Center. http://etc.org/advanced-technologies/high-temperature-incineration.aspx

Envirologic Data (Envirologic Data, Inc.). (1992). Assessment of risks from potential exposure to airbourne facility emissions under California AB 2588 for the Rohr Inc Facility Riverside, Calif (vol. 1) (final report) w-letter [TSCA Submission]. (OTS0536860. 86-920001002. TSCATS/426535). Rohr Incorporated. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/OTS0536860.xhtml

EPA, USEPAUS. (1994). Guidelines for Statistical Analysis of Occupational Exposure Data: Final. United States Environmental Protection Agency :: U.S. EPA.

ESIG (European Solvents Industry Group). (2012). SPERC fact sheet: Formulation & (re)packing of substances and mixtures – Industrial (solvent-borne). Brussels, Belgium.

Greene, K; Pennington, RE. (1977). Petrochemical outlook .4. butadiene. Chemical Engineering Progress 73: 36-39.

Grub, J; Löser, E. (2011). Butadiene. In Ullmann's Encyclopedia of Industrial Chemistry. Weinheim, Germany: Wiley-VCH Verlag GmbH & Co. http://dx.doi.org/10.1002/14356007.a04_431.pub2

Heritage. (2018). Heritage website. Retrieved from https://www.heritage-enviro.com/services/incineration/

Highline Warren (Highline Warren LLC). (2015). Safety Data Sheet (SDS): Rubber patch. Memphis, TN. https://www.truflate.com/_files/ugd/144108_e77c18aca208481c8f3d889e15458409.pdf

IARC (International Agency for Research on Cancer). (1986). 1,3-Butadiene. In Some chemicals used in plastics and elastomers (pp. 155-179). Lyon, France.

Kitto, JB; Stultz, SC. (1992). Steam: Its generation and use (40th ed.). Barberton, OH: Babcock & Wilcox.

Krishnan, E; Ungers, L; Morelli-Schroth, P; Fajen, J. (1987). Extent of exposure study: 1,3-butadiene monomer production industry. Cincinnati, OH: U.S. Department of Health and Human Services. https://ntrl.ntis.gov/NTRL/dashboard/searchResults/titleDetail/PB87229647.xhtml

Lee, N; Lee, BK; Jeong, S; Yi, GY; Shin, J. (2012). Work environments and exposure to hazardous substances in Korean tire manufacturing. Saf Health Work 3: 130-139. http://dx.doi.org/10.5491/SHAW.2012.3.2.130

Miller, LM; Villaume, JE. (1978). Investigation of selected potential environmental contaminants: 1,3 Butadiene-Final report [EPA Report]. (EPA 560/2-78-003). Washington, DC: U.S. Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyNET.exe/910036J7.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1976+Thru+1980&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C76thru80%5CTxt%5C00000010%5C910036J7.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

NIOSH (National Institute for Occupational Safety and Health). (1992). Occupational safety and health guideline for butadiene (1,3-butadiene). U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health.

Niosh. (2003). Respirator Usage in Private Sector Firms. Washington D.C.: United States Department of Labor, Bureau of Labor Statistics and National Institute for Occupational Safety and Health. https://www.cdc.gov/niosh/docs/respsurv/

NLM (National Library of Medicine). (2003). PubChem: Hazardous Substance Data Bank: 1,3-Butadiene, 106-99-0. Available online at https://pubchem.ncbi.nlm.nih.gov/compound/7845#source=HSDB

NRCe (National Response Center). (2009). Query/download NRC FOIA data [Database]. Retrieved from http://www.nrc.uscg.mil/foia.html

OECD (Organisation for Economic Co-operation and Development). (2009a). Emission scenario document on adhesive formulation. (ENV/JM/MONO(2009)3; JT03263583). Paris, France. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2009)3&doclanguage=en

OECD (Organisation for Economic Co-operation and Development). (2009b). Emission scenario document on plastic additives. In Series on Emission Scenario Documents No 3. (JT03267870). Paris, France: OECD Environmental Health and Safety Publications. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2004)8/rev1&doclanguage=en

OECD (Organisation for Economic Co-operation and Development). (2009c). Emission scenario documents on coating industry (paints, lacquers and varnishes). (JT03267833). Paris, France. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env%20/jm/mono(2009)24&doclanguage=en

OECD (Organisation for Economic Co-operation and Development). (2010). Emission scenario document on formulation of radiation curable coatings, inks and adhesives. In Series on Emission Scenario Documents No 21. Paris, France: OECD Environmental Health and Safety Publications. https://www.oecd-ilibrary.org/docserver/9789264221109-en.pdf?expires=1591023963&id=id&accname=guest&checksum=D62CF543E560282B5F4F94355EB4DFC7

OECD (Organisation for Economic Co-operation and Development). (2011a). Emission scenario document on coating application via spray-painting in the automotive refinishing industry. (ENV/JM/MONO(2004)22/REV1). Paris, France: Organization for Economic Co-operation and Development. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2004)22/rev1&doclanguage=en

OECD (Organisation for Economic Co-operation and Development). (2011b). Emission Scenario Document on the application of radiation curable coatings, inks, and adhesives via spray, vacuum, roll, and curtain coating.

OECD (Organisation for Economic Co-operation and Development). (2013). Emission scenario document on the industrial use of adhesives for substrate bonding. Paris, France.

OECD (Organisation for Economic Co-operation and Development). (2015a). Emission scenario document on the use of adhesives. (JT03373626). Paris, France. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO(2015)4&doclanguage=en

OECD (Organisation for Economic Co-operation and Development). (2015b). Emission scenario document on use of adhesives. (Number 34). Paris, France. http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO(2015)4&doclanguage=en

OECD (Organisation for Economic Co-operation and Development). (2020). Emission scenario document on chemical additives used in automotive lubricants. Paris, France.

PEI Associates. (1988). Releases during cleaning of equipment. Washington, DC: U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. https://ofmpub.epa.gov/apex/guideme_ext/guideme/file/releases%20during%20cleaning%20of%20equipment.pdf

Penman, M; Banton, M; Erler, S; Moore, N; Semmler, K. (2015). Olefins and chemical regulation in Europe: REACH. Chem Biol Interact 241: 59-65. http://dx.doi.org/10.1016/j.cbi.2015.04.001

Peterson, CA; Key, JA; Hobbs, FD; Blackburn JW, B, asdekis, H. S.; Dylewski, SW; Standifer, RL; Helsel, RW. (1980). Organic chemical manufacturing : Selected processes, volume 10. (EPA-450/3-80-028e). U.S. Environmental Protection Agency. https://nepis.epa.gov/Exe/ZyNET.exe/9101OKIA.TXT?ZyActionD=ZyDocument&Client=EPA&Index=1976+Thru+1980&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C76thru80%5CTxt%5C00000033%5C9101OKIA.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

Pfäffli, P; Säämänen, A. (1993). The occupational scene of styrene. In M Sorsa; K Peltonen; H Vainio; K Hemminki (Eds.), Butadiene and styrene: Assessment of health hazards (pp. 15-26). Geneva, Switzerland: World Health Organization. https://search.proquest.com/docview/76299947?accountid=171501

Roper, CP, Jr. (1976). Health Hazard Evaluation Determination, Report No. 74-120-260, Goodyear Tire and Rubber Company, Gadsden, Alabama. (HHE-74-120-260). Cincinnati, OH: National Institute for Occupational Safety and Health. https://www.cdc.gov/niosh/hhe/reports/pdfs/74-120-260.pdf

Sigma-Aldrich (Sigma-Aldrich Corporation). (2024). Safety data sheet (SDS): 1,3-Butadiene. St. Louis, MO: Sigma-Aldrich Inc. https://www.sigmaaldrich.com/US/en/sds/ALDRICH/295035

Steinle, P. (2016). Characterization of emissions from a desktop 3D printer and indoor air measurements in office settings. J Occup Environ Hyg 13: 121-132. http://dx.doi.org/10.1080/15459624.2015.1091957

Sun, HN; Wristers, JP. (2002). Butadiene. In Kirk-othmer encyclopedia of chemical technology (1999-2013). New York, NY: John Wiley & Sons. http://dx.doi.org/10.1002/0471238961.02212001192114.a01.pub2

Suresh, SS; Bonda, S; Mohanty, S; Nayak, SK. (2018). A review on computer waste with its special insight to toxic elements, segregation and recycling techniques. Process Saf Environ Prot 116: 477-493. http://dx.doi.org/10.1016/j.psep.2018.03.003

ToxStrategies. (2021). Analysis of 1,3-butadiene industrial hygiene data. Washington, DC: American Chemistry Council.

U.S. BLS (U.S. Bureau of Labor Statistics). (2014). Employee Tenure News Release. Available online at http://www.bls.gov/news.release/archives/tenure_09182014.htm

U.S. BLS (U.S. Bureau of Labor Statistics). (2016). May 2016 Occupational Employment and Wage Estimates: National Industry-Specific Estimates. Available online at http://www.bls.gov/oes/tables.htm

U.S. BLS (U.S. Bureau of Labor Statistics). (2023). U.S. Census Bureau of Labor Statistics Data from 2021. Washington, DC: United States Department of Labor. Retrieved from https://www.bls.gov/oes/tables.htm

U.S. Census Bureau. (2015). Statistics of U.S. Businesses (SUSB). https://www.census.gov/data/tables/2015/econ/susb/2015-susb-annual.html

U.S. Census Bureau. (2019a). Survey of Income and Program Participation data. Available online at https://www.census.gov/programs-surveys/sipp/data/datasets/2008-panel/wave-1.html (accessed May 16, 2019).

U.S. Census Bureau. (2019b). Survey of Income and Program Participation: SIPP introduction and history. Washington, DC. https://www.census.gov/programs-surveys/sipp/about/sipp-introduction-history.html

U.S. Department of Transportation. (2024). DOT Hazmat Incident Report Search Tool [Database]. Washington, DC: Pipeline and Hazardous Materials Safety Administration. Retrieved from https://portal.phmsa.dot.gov/phmsapub/faces/PHMSAHome?req=-9131165071453289684&attempt=0

U.S. EPA (U.S. Environmental Protection Agency). (1992). Guidelines for exposure assessment. Federal Register 57(104):22888-22938 [EPA Report]. In Risk Assessment Forum. (EPA/600/Z-92/001). Washington, DC. http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=15263

U.S. EPA (U.S. Environmental Protection Agency). (1996). Locating and estimating air emissions from sources of 1,3-butadiene. (EPA 454/R-96-008). https://www3.epa.gov/ttn/chief/le/butadien.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2004). Additives in plastics processing (converting into finished products) -generic scenario for estimating occupational exposures and environmental releases. Draft. Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). (2011). Exposure factors handbook: 2011 edition [EPA Report]. (EPA/600/R-090/052F). Washington, DC: U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment. https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100F2OS.txt

U.S. EPA (U.S. Environmental Protection Agency). (2013). ChemSTEER user guide - Chemical screening tool for exposures and environmental releases. Washington, D.C. https://www.epa.gov/sites/production/files/2015-05/documents/user_guide.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2014). Formulation of waterborne coatings - Generic scenario for estimating occupational exposures and environmental releases -Draft.

Washington, DC. https://www.epa.gov/tsca-screening-tools/using-predictive-methods-assess-exposure-and-fate-under-tsca

U.S. EPA (U.S. Environmental Protection Agency). (2016). Chemical Data Reporting (CDR): Complete 2016 submissions. Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). Hazardous Waste Management Facilities and Units. Available online at https://www.epa.gov/hwpermitting/hazardous-waste-management-facilities-and-units

U.S. EPA (U.S. Environmental Protection Agency). (2019a). Learn the Basics of Hazardous Waste. Available online at https://www.epa.gov/hw/learn-basics-hazardous-waste

U.S. EPA (U.S. Environmental Protection Agency). (2019b). National Emissions Inventory (NEI) [database]: CASRNs 79-00-5, 75-34-3, 107-06-2, 78-87-5, 84-61-7, 106-99-0, 106-93-4, 50-00-0, 85-44-9, 106-46-7, 85-68-7, 84-74-2, 117-81-7, and 115-86-6 [Database]. Washington, DC. Retrieved from https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei

U.S. EPA (U.S. Environmental Protection Agency). (2019c). Synthetic turf field recycled tire crumb rubber research under the Federal Research Action Plan, Final report part 1: Tire crumb rubber characterization, volume 1. (EPA/600/R-19/051.1). Washington, DC: U.S. Environmental Protection Agency, ATSDR, CDC. https://www.epa.gov/sites/default/files/2019-08/documents/synthetic_turf_field_recycled_tire_crumb_rubber_research_under_the_federal_research_action_plan_final_report_part_1_volume_1.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2020a). 2020 CDR Data [Database]. Washington, DC. Retrieved from https://www.epa.gov/chemical-data-reporting/access-cdr-data#2020

U.S. EPA (U.S. Environmental Protection Agency). (2020b). 2020 CDR: Commercial and consumer use. Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). (2020c). Final scope of the risk evaluation for 1,3-butadiene; CASRN 106-99-0. (EPA 740-R-20-011). Washington, DC: Office of Chemical Safety and Pollution Prevention. https://www.epa.gov/sites/default/files/2020-09/documents/casrn_106-99-0_13-butadiene_finalscope.pdf

U.S. EPA (U.S. Environmental Protection Agency). (2021a). Draft systematic review protocol supporting TSCA risk evaluations for chemical substances, Version 1.0: A generic TSCA systematic review protocol with chemical-specific methodologies. (EPA Document #EPA-D-20-031). Washington, DC: Office of Chemical Safety and Pollution Prevention. https://www.regulations.gov/document/EPA-HQ-OPPT-2021-0414-0005

U.S. EPA (U.S. Environmental Protection Agency). (2021b). National analysis TRI dataset (TRI): Data used for TSCA risk evaluations, reporting year 2019 [Database]. Retrieved from https://www.epa.gov/toxics-release-inventory-tri-program/tri-listed-chemicals

U.S. EPA (U.S. Environmental Protection Agency). (2021c). Use of additives in plastic compounding – Generic scenario for estimating occupational exposures and environmental releases (Revised draft) [EPA Report]. Washington, DC: Office of Pollution Prevention and Toxics, Risk Assessment Division.

U.S. EPA (U.S. Environmental Protection Agency). (2021d). Use of additives in plastics converting – Generic scenario for estimating occupational exposures and environmental releases (revised draft). Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA (U.S. Environmental Protection Agency). (2022). Chemical repackaging - Generic scenario for estimating occupational exposures and environmental releases (revised draft) [EPA Report]. Washington, DC.

U.S. EPA (U.S. Environmental Protection Agency). (2023). Use of laboratory chemicals - Generic scenario for estimating occupational exposures and environmental releases (Revised draft generic scenario) [EPA Report]. Washington, DC: U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, Existing Chemicals Risk Assessment Division.

U.S. EPA (U.S. Environmental Protection Agency). (2024a). Draft Adhesives and Sealants Release Model for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics. https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425

U.S. EPA (U.S. Environmental Protection Agency). (2024b). Draft Air Releases (NEI2017) for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics. https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425

U.S. EPA (U.S. Environmental Protection Agency). (2024c). Draft Air Releases (NEI2020) for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics. https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425

U.S. EPA (U.S. Environmental Protection Agency). (2024d). Draft Air Releases (TRI) for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics. https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425

U.S. EPA (U.S. Environmental Protection Agency). (2024e). Draft Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA (U.S. Environmental Protection Agency). (2024f). Draft Land Releases for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics. https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425

U.S. EPA (U.S. Environmental Protection Agency). (2024g). Draft Number of Sites for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics. https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425

U.S. EPA (U.S. Environmental Protection Agency). (2024h). Draft Physical Chemistry and Fate Assessment for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA (U.S. Environmental Protection Agency). (2024i). Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA (U.S. Environmental Protection Agency). (2024j). Draft Risk Evaluation for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA (U.S. Environmental Protection Agency). (2024k). Draft Systematic Review Protocol for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics.

U.S. EPA (U.S. Environmental Protection Agency). (2024l). Draft Water Releases for 1,3-Butadiene. Washington, DC: Office of Pollution Prevention and Toxics. https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425

USTMA (U.S. Tire Manufacturers Association). (2020). Comment regarding 1,3-butadiene, submitted by U.S. Tire Manufacturers Association (USTMA), dated 05/26/2020. (EPA-HQ-OPPT-2018-0451-0037). Washington, DC. https://www.regulations.gov/comment/EPA-HQ-OPPT-2018-0451-0037

Valero. (2018). Safety data sheet (SDS): Butane (SDS number 0106, Version #.03, Revision date 02 March 2018). Montreal, Quebec: Énergie Valero Inc. https://www.valero.com/sites/default/files/2019-12/0106_butane_canada_eng.pdf

Appendix A ESTIMATING NUMBER OF WORKERS AND OCCUPATIONAL NON-USERS

This appendix summarizes the methods that EPA used to estimate the number of workers who are potentially exposed to 1,3-butadiene in each of its conditions of use. 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 condition of use.
3. Estimate total employment by industry/occupation combination using the Bureau of Labor Statistics' Occupational Employment Statistics data (U.S. BLS, 2023).
4. Refine the Occupational Employment Statistics data estimates where they are not sufficiently granular by using the U.S. Census' (U.S. BLS, 2023) SUSB data on total employment by 6-digit NAICS.
5. Estimate the percentage of employees likely to be using 1,3-butadiene instead of other chemicals (*i.e.*, the market penetration of 1,3-butadiene 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 condition of use.

Step 1: Identifying Affected NAICS Codes

As a first step, EPA identified NAICS industry codes associated with each condition of use. EPA generally identified NAICS industry codes for a condition of use by

- Querying the U.S. Census Bureau's *NAICS Search* tool using keywords associated with each condition of use to identify NAICS codes with descriptions that match the condition of use.
- Referencing EPA GSs and Organisation for Economic Co-operation and Development (OECD) ESDs for a condition of use 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, 2020b).

Each COU section in the main body of this draft assessment identifies the NAICS codes EPA 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 (U.S. BLS, 2023). The industries are classified by NAICS codes (identified previously), and occupations are classified by SOC codes.

Among the relevant NAICS codes (identified previously), EPA reviewed the occupation description and identified those occupations (SOC codes) where workers are potentially exposed to 1,3-butadiene. Table_Apx A-1 shows the SOC codes EPA classified as occupations potentially exposed to 1,3-butadiene. These occupations are classified as workers (W) and ONU (O). All other SOC codes are assumed to represent occupations where exposure is unlikely.

Table_Apx A-1. SOCs with Worker and ONU Designations for All Conditions of Use Except Dry Cleaning

SOC	Occupation	Designation
11-9020	Construction Managers	O
17-2000	Engineers	O
17-3000	Drafters, Engineering Technicians, and Mapping Technicians	O
19-2031	Chemists	O
19-4000	Life, Physical, and Social Science Technicians	O
47-1000	Supervisors of Construction and Extraction Workers	O
47-2000	Construction Trades Workers	W
49-1000	Supervisors of Installation, Maintenance, and Repair Workers	O
49-2000	Electrical and Electronic Equipment Mechanics, Installers, and Repairers	W
49-3000	Vehicle and Mobile Equipment Mechanics, Installers, and Repairers	W
49-9010	Control and Valve Installers and Repairers	W
49-9020	Heating, Air Conditioning, and Refrigeration Mechanics and Installers	W
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	W
49-9060	Precision Instrument and Equipment Repairers	W
49-9070	Maintenance and Repair Workers, General	W
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	W
51-1000	Supervisors of Production Workers	O
51-2000	Assemblers and Fabricators	W
51-4020	Forming Machine Setters, Operators, and Tenders, Metal and Plastic	W
51-6010	Laundry and Dry-Cleaning Workers	W
51-6020	Pressers, Textile, Garment, and Related Materials	W
51-6030	Sewing Machine Operators	O
51-6040	Shoe and Leather Workers	O
51-6050	Tailors, Dressmakers, and Sewers	O
51-6090	Miscellaneous Textile, Apparel, and Furnishings Workers	O
51-8020	Stationary Engineers and Boiler Operators	W
51-8090	Miscellaneous Plant and System Operators	W
51-9000	Other Production Occupations	W
W = worker designation; O = ONU designation		

For dry cleaning facilities, due to the unique nature of work expected at these facilities and that different workers may be expected to share among activities with higher exposure potential (*e.g.*, unloading the dry-cleaning machine, pressing/finishing a dry-cleaned load), EPA made different SOC code worker and ONU assignments for this COU. Table_Apx A-2 summarizes the SOC codes with worker and ONU

designations used for dry cleaning facilities.

Table_Apx A-2. SOCs with Worker and ONU Designations for Dry Cleaning Facilities

SOC	Occupation	Designation
41-2000	Retail Sales Workers	O
49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	W
49-9070	Maintenance and Repair Workers, General	W
49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	W
51-6010	Laundry and Dry-Cleaning Workers	W
51-6020	Pressers, Textile, Garment, and Related Materials	W
51-6030	Sewing Machine Operators	O
51-6040	Shoe and Leather Workers	O
51-6050	Tailors, Dressmakers, and Sewers	O
51-6090	Miscellaneous Textile, Apparel, and Furnishings Workers	O

After identifying relevant NAICS and SOC codes, EPA used BLS data to determine total employment by industry and by occupation based on the NAICS and SOC combinations. For example, there are 110,640 employees associated with 4-digit NAICS 8123 (Drycleaning and Laundry Services) and SOC 51-6010 (Laundry and Dry-Cleaning 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's methodology was to further refine the employment estimates by using total employment data in the U.S. Census Bureau's SUSB (U.S. BLS, 2023). In some cases, BLS's Occupational Employment Statistics' occupation-specific data are only available at the 4-digit 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 1,3-butadiene exposure are included. As an example, Occupational Employment Statistics data are available for the 4-digit NAICS 8123 (Drycleaning and Laundry Services), which includes the following 6-digit NAICS:

- NAICS 812310 Coin-Operated Laundries and Drycleaners;
- NAICS 812320 Drycleaning and Laundry Services (except Coin-Operated);
- NAICS 812331 Linen Supply; and
- NAICS 812332 Industrial Launderers.

In this example, only NAICS 812320 is of interest. The census data allow EPA 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 812320 comprises 46 percent of total employment under the 4-digit NAICS 8123.

This percentage can be multiplied by the occupation-specific employment estimates given in the BLS Occupational Employment Statistics data to further refine our estimates of the number of employees with potential exposure. Table_Apx A-3 illustrates this granularity adjustment for NAICS 812320.

Table_Apx A-3. Estimated Number of Potentially Exposed Workers and ONUs under NAICS 812320

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
8123	41-2000	Retail Sales Workers	O	44,500	46.0%	20,459
8123	49-9040	Industrial Machinery Installation, Repair, and Maintenance Workers	W	1,790	46.0%	823
8123	49-9070	Maintenance and Repair Workers, General	W	3,260	46.0%	1,499
8123	49-9090	Miscellaneous Installation, Maintenance, and Repair Workers	W	1,080	46.0%	497
8123	51-6010	Laundry and Dry-Cleaning Workers	W	110,640	46.0%	50,867
8123	51-6020	Pressers, Textile, Garment, and Related Materials	W	40,250	46.0%	18,505
8123	51-6030	Sewing Machine Operators	O	1,660	46.0%	763
8123	51-6040	Shoe and Leather Workers	O	Not Reported for this NAICS Code		
8123	51-6050	Tailors, Dressmakers, and Sewers	O	2,890	46.0%	1,329
8123	51-6090	Miscellaneous Textile, Apparel, and Furnishings	O	0	46.0%	0

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
		Workers				
Total Potentially Exposed Employees				**206,070**		**94,740**
Total Workers						**72,190**
Total Occupational Non-users						**22,551**

W = worker; O = occupational non-user
Note: numbers may not sum exactly due to rounding
Source: U.S. BLS (2016), U.S. Census Bureau (2015)

Step 4: Estimating the Percentage of Workers Using 1,3-Butadiene Instead of Other Chemicals

In the final step, EPA accounted for the market share by applying a factor to the number of workers determined in Step 3. This accounts for the fact that 1,3-butadiene may be only one of multiple chemicals used for the applications of interest. EPA/OPPT did not identify market penetration data for any conditions of use. In the absence of market penetration data for a given COU, EPA assumed 1,3-butadiene 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 per Site

EPA calculated the number of workers and ONU 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) × Granularity Adjustment Percentage (Step 3) = Number of Workers or ONUs in the Industry/Occupation Combination

EPA then estimated the total number of establishments by obtaining the number of establishments reported in the U.S. Census Bureau's SUSB (U.S. BLS, 2023) data at the 6-digit NAICS level.

The Agency then summed the number of workers and ONU 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 ONU per site.

Step 6: Estimating the Number of Workers and Sites for a Condition of Use

EPA estimated the number of workers and ONU potentially exposed to 1,3-butadiene and the number of sites that use 1,3-butadiene in a given condition of use through the following steps:

1. Obtaining the total number of establishments by:
    a. 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
    b. Obtaining the number of establishments from the TRI, DMR, NEI, or literature for the COU.
2. Estimating the number of establishments that use 1,3-butadiene by taking the total number of establishments from 1a and multiplying it by the market penetration factor from Step 4.

3. Estimating the number of workers and ONU potentially exposed to 1,3-butadiene by taking the number of establishments calculated in 1b and multiplying it by the average number of workers and ONU per site from Step 5.

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

This report assesses 1,3-butadiene 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, and lifetime average daily concentrations (LADC) 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 less than one 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.

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

Where:

$ADC_{intermediate}$	=	Intermediate average daily concentration
$EF_{intermediate}$	=	Intermediate exposure frequency
$AT_{intermediate}$	=	Averaging time (hr) 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 (hr/day)
EF = Exposure frequency (day/yr)
WY = Working years per lifetime (yr)
AT = Averaging time (hr) for chronic, non-cancer risk
AT_C = Averaging time (hr) for cancer risk
LT = Lifetime years (yr) for cancer risk

B.2 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*	5-260[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

Parameter Name	Symbol	Value	Unit
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.2.1 Exposure Duration (ED)

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

B.2.2 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/hr (CEB, 1991) while the resting breathing rate is 0.6125 m^3/hr (CEB, 1991). The ratio of these two values is equivalent to 2.04.

B.2.3 Exposure Frequency (EF)

EPA generally uses a maximum exposure frequency of 250 days per year for 8-hr TWA estimates, and 167 days/yr for 12-hourr TWA estimates. For the application of paints, coatings, adhesives, and sealants OES, EPA used a high-end of 260 days/yr based on the Use of Adhesives ESD (OECD, 2015a).

EF is expressed as the number of days per 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-7.

$$EF = f \times AWD$$

Where:

EF = Exposure frequency, the number of days per 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 per year a worker works (day/yr)

BLS (U.S. BLS, 2023) 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 per 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, EPA looked up the average hours worked per employee per year at the most granular NAICS level available (*i.e.*, 4-, 5-, or 6-digit).

EPA converted the working hours per employee to working days per year per employee assuming employees work an average of 8 hours per day. The average number of days per year worked, or AWD, ranges from 169 to 282 days per year, with a 50th percentile value of 250 days per 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 per year, with a 50th percentile value of 228 days per year. 250 days per year is approximately the 75th percentile. In the absence of industry- and 1,3-butadiene-specific data, EPA assumes the parameter *f* is equal to one for all conditions of use.

B.2.4 Intermediate Exposure Frequency ($EF_{intermediate}$)

For 1,3-butadiene, 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-8.

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

B.2.5 Intermediate Duration ($D_{intermediate}$)

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

B.2.6 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 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 (U.S. BLS, 2023) provides information on employee tenure with *current employer* obtained from the Current Population Survey (CPS). CPS 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 two 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 cross-walked 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.[8] 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. EPA 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 analysis.

Table_Apx B-2 summarizes the average tenure for workers age 50 and older from SIPP data. 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 10 chemicals undergoing 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 less than five 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 aged 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+ years	4.1	4.4	4.6	4.6
16–17	0.7	0.7	0.7	0.7
18–19	0.8	1.0	0.8	0.8

[8] 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).

Age (years)	January 2008	January 2010	January 2012	January 2014
20–24	1.3	1.5	1.3	1.3
25+	5.1	5.2	5.4	5.5
25–34	2.7	3.1	3.2	3.0
35–44	4.9	5.1	5.3	5.2
45–54	7.6	7.8	7.8	7.9
55–64	9.9	10.0	10.3	10.4
65+	10.2	9.9	10.3	10.3
Source: (U.S. BLS, 2014)				

B.2.7 Lifetime Years (LT)

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

B.2.8 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 (HE) and central tendency (CT) 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 Calculations

Calculate AC_{HE}:

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

$$AC_{HE} = \frac{0.45\ ppm \times 8\ hr/day \times 2.04}{24\ hr/day} = 0.31\ ppm$$

Calculate $ADC_{Intermediate, HE}$:

$$ADC_{Intermediate} = \frac{C_{HE} \times ED \times EF_{Intermediate} \times BR}{AT_{Intermediate}}$$

$$ADC_{Intermediate,HE} = \frac{0.45\ ppm \times 8\frac{hr}{day} \times 22\frac{days}{year} \times 2.04}{24\frac{hr}{day} \times 30\frac{days}{year}} = 0.22\ ppm$$

Calculate ADC_{HE}:

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

$$ADC_{HE} = \frac{0.45\ ppm \times 8\frac{hr}{day} \times 350\frac{days}{year} \times 40\ years \times 2.04}{40\ years \times 365\frac{days}{yr} \times 24\frac{hr}{day}} = 0.22\ ppm$$

Calculate $LADC_{HE}$:

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

$$LADC_{HE} = \frac{0.45\ ppm \times 8\frac{hr}{day} \times 350\frac{days}{year} \times 40\ years \times 2.04}{78\ years \times 365\frac{days}{year} \times 24\ hr/day} = 5.5 \times 10^{-2}\ ppm$$

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

Calculate AC_{CT}:

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

$$AC_{CT} = \frac{2.5 \times 10^{-2}\ ppm \times 8\ hr/day \times 2.04}{24\ hr/day} = 1.7 \times 10^{-2}\ ppm$$

Calculate $ADC_{Intermediate,\ CT}$:

$$ADC_{Int,CT} = \frac{C_{CT} \times ED \times EF_{Intermediate} \times BR}{AT_{Intermediate}}$$

$$ADC_{Intermediate,CT} = \frac{2.5 \times 10^{-2}\ ppm \times 8\frac{hr}{day} \times 22\frac{days}{year} \times 2.04}{24\frac{hr}{day} \times 30\frac{days}{year}} = 1.2 \times 10^{-2}\ ppm$$

Calculate ADC_{CT}:

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

$$ADC_{CT} = \frac{2.5 \times 10^{-2}\ ppm \times 8\frac{hr}{day} \times 350\frac{days}{year} \times 31\ years \times 2.04}{31\ years \times 365\frac{days}{yr} \times 24\frac{hr}{day}} = 1.2 \times 10^{-2}\ ppm$$

Calculate $LADC_{CT}$:

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

$$LADC_{CT} = \frac{2.5 \times 10^{-2}\ ppm \times 8\frac{hr}{day} \times 350\frac{days}{year} \times 31\ years \times 2.04}{78\ years \times 365\frac{days}{year} \times 24\ hr/day} = 2.4 \times 10^{-3}\ ppm$$

Appendix D MODEL APPROACHES AND PARAMETERS

This appendix presents the modeling approach and model equations used in estimating environmental releases and occupational exposures for each of the applicable OESs. 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.

For 1,3-butadiene, only one site in NEI mapped to the Application of adhesives and sealants OES, which EPA did not believe was sufficient to be representative of all possible releases that may occur from this OES. Therefore, the Agency developed a Monte Carlo simulation using EPA/OPPT standard models, 1,3-butadiene product SDSs, CDR data, and GSs or ESDs to represent the potential releases typical of the Application of adhesives and sealants OES.

D.1 EPA/OPPT Standard Models

This appendix section discusses the standard models used by EPA to estimate environmental releases of chemicals. EPA did not use any standard models to estimate occupational exposure to workers. All the models presented in this section are models that were previously developed by EPA and are not the result of any new model development work for this risk evaluation. Therefore, this appendix does not provide the details of the derivation of the model equations which have been provided in other documents such as the ChemSTEER User Guide (U.S. EPA, 2013), Chemical Engineering Branch Manual for the Preparation of Engineering Assessments, Volume 1 (CEB, 1991), Evaporation of Pure Liquids from Open Surfaces (Arnold and Engel, 2001), and Releases During Cleaning of Equipment (PEI Associates, 1988). The models include loss fraction models as well as models for estimating chemical vapor generation rates used in subsequent model equations to estimate the volatile releases to air. The parameters in the equations of this appendix section are specific to calculating environmental releases of 1,3-butadiene.

The EPA/OPPT Penetration Model and EPA/OPPT Mass Transfer Coefficient Model are used to estimate volatile chemical releases from an open, exposed liquid surface; however, these models cannot be used for chemicals with a vapor pressure above 35 torr. Therefore, these models cannot be used for 1,3-butadiene. Instead, to assess air releases that would otherwise be assessed with these models, EPA used a mass balance approach by assuming 100 percent release and subtracting the releases that could be quantified with other models/approaches from the daily 1,3-butadiene use rate.

The EPA Office of Air Quality Planning and Standards (OAQPS) AP-42 Loading Model estimates releases to air from the displacement of air containing chemical vapor as a container/vessel is filled with

a liquid. This model assumes that the rate of evaporation is negligible compared to the vapor loss from the displacement and is used as the default for estimating volatile air releases during both loading activities and unloading activities. This model is used for unloading activities because it is assumed while one vessel is being unloaded another is assumed to be loaded. The EPA/OAQPS AP-42 Loading Model calculates the average vapor generation rate from loading or unloading using the following equation:

Equation_Apx D-1.

$$G_{activity} = \frac{F_{saturation\_factor} * MW_{1,3-BD} * V_{container} * 3785.4 \frac{cm^3}{gal} * F_{correction\_factor} * VP * \frac{RATE_{fill}}{3600 \frac{s}{hr}}}{R * T}$$

Where:

$G_{activity}$	=	Vapor generation rate for activity [g/s]
$F_{saturation\_factor}$	=	Saturation factor [unitless]
$MW_{1,3-BD}$	=	1,3-butadiene (1,3-BD) molecular weight [g/mol]
$V_{container}$	=	Volume of container [gal/container]
$F_{correction\_factor}$	=	Vapor pressure correction factor [unitless]
VP	=	1,3-butadiene vapor pressure [torr]
$RATE_{fill}$	=	Fill rate of container [containers/hr]
R	=	Universal gas constant [L*torr/mol-K]
T	=	Temperature [K]

The vapor pressure correction factor ($F_{correction\_factor}$) can be estimated using Raoult's Law and the mole fraction of 1,3-butadiene in the liquid of interest.

When calculating an environmental release, the vapor generation rate from Equation_Apx D-1 is then used along with an operating time to calculate the release amount:

Equation_Apx D-2.

$$Release\_Year_{activity} = Time_{activity} * G_{activity} * 3600 \frac{s}{hr} * 0.001 \frac{kg}{g}$$

Where:

$Release\_Year_{activity}$	=	1,3-Butadiene released for activity per site-year [kg/site-yr]
$Time_{activity}$	=	Operating time for activity [hr/site-yr]
$G_{activity}$	=	Vapor generation rate for activity [g/s]

In addition to the EPA/OAQPS AP-42 Loading Model, EPA uses various loss fraction models to calculate environmental releases, including the following:

- EPA/OPPT Small Container Residual Model
- EPA/OPPT Drum Residual Model
- EPA/OPPT Multiple Process Vessel Residual Model
- EPA/OPPT Single Process Vessel Residual Model

The loss fraction models apply a given loss fraction to the overall throughput of 1,3-butadiene for the given process. The loss fraction value or distribution of values differs for each model; however, the models each follow the same general equation:

Equation_Apx D-3.

$$Release\_Year_{activity} = Q_{1,3-BD,yr} * F_{activity\_loss}$$

Where:

$Release\_Year_{activity}$	=	1,3-Butadiene released for activity per site-year [kg/site-yr]
$Q_{1,3-BD,yr}$	=	Annual facility throughput of 1,3-butadiene [kg/site-yr]
$F_{activity\_loss}$	=	Loss fraction for activity [unitless]

EPA references the model equations by model name and/or equation number within the rest of this appendix.

D.2 Application of Adhesives and Sealants Model Approaches and Parameters for Environmental Release

This appendix presents the modeling approach and equations used to estimate environmental releases of 1,3-butadiene during the application of adhesives and sealants OES. This approach utilizes the ESD on the Use of Adhesives (OECD, 2013) combined with Monte Carlo simulation (a type of stochastic simulation). To review the Application of Adhesives and Sealants release model, see the *Draft Adhesives and Sealants Release Model for 1,3-Butadiene* (U.S. EPA, 2024a).

Based on the ESD, EPA identified the following release sources from the application of adhesives and sealants:

- Release source 1: Adhesive Component Container Residue.
- Release source 2: Open Surface Losses During Container Cleaning (N/A – due to chemical's volatility, assessed as part of a 100% release scenario and incorporated into release source 6).
- Release source 3: Transfer Operation Losses to Air from Unloading the Adhesive Formulation.
- Release source 4: Equipment Cleaning Releases.
- Release source 5: Open Surface Losses During Equipment Cleaning (N/A – due to chemical's volatility, assessed as part of a 100% release scenario and incorporated into release source 6).
- Release source 6: All Other Process Releases, Including Volatilization, Application, and Curing.

Environmental releases for 1,3-butadiene during the application of adhesives and sealants are a function of 1,3-butadiene'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: ventilation rate, mixing factor, air speed, saturation factor, loss factor, container sizes, working years, and drum fill rates. 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.

D.2.1 Model Equations

Table_Apx D-1 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the Application of adhesives and sealants OES. The variables used to calculate each of the following values include deterministic or

variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix D.2.2. The Monte Carlo simulation calculated the total 1,3-butadiene release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx D-1. Models and Variables Applied for Release Sources in the Application of Adhesives and Sealants OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Adhesive Component Container Residue	*EPA/OPPT Small Container Residual Model* (Equation_Apx D-3)	$F_{1,3-BD}$; $N_{cont\_unload\_day}$; $F_{residue}$; RHO; V_{cont}; $Q_{1,3-BD\_day}$
Release source 2: Open Surface Losses During Container Cleaning (not assessed).	N/A; assessed as part of a 100% release scenario.	N/A
Release source 3: Transfer Operation Losses to Air from Unloading the Adhesive Formulation	*EPA/OAQPS AP-42 Loading Model* (Equation_Apx D-1)	$F_{1,3-BD}$; VP; f_{sat}; MW; V_{cont}; R; T; $RATE_{fill}$
Release source 4: Equipment Cleaning Releases.	*EPA/OPPT Single Process Residual Model* (Equation_Apx D-3)	$Q_{1,3\text{-}BD}$; $F_{equipment\_cleaning}$
Release source 5: Open Surface Losses During Equipment Cleaning (not assessed)	This release was assessed with release source 6, as part of a 100% release scenario.	N/A
Release source 6: All Other Process Releases, Including Volatilization, Application, and Curing	100% release scenario (Equation_Apx D-4)	$Q_{1,3\text{-}BD\_day}$

For 1,3-butadiene, release source 6 (all other process releases, including volatilization, application, and curing) is calculated via a mass balance, via the following equation:

Equation_Apx D-4.

$$Release\_perDay_{RP6} = Q_{1,3-BD\_day} - Release_{perDay_{RP1}} - Release_{perDay_{RP3}} - Release\_perDay_{RP4}$$

Where:

$Release\_perDay_{RP6}$ = 1,3-Butadiene released for release source 6 [kg/site-day]
$Q_{1,3\text{-}BD\_day}$ = Facility daily throughput of 1,3-butadiene [kg/site-day]
$Release\_perDay_{RP1}$ = 1,3-Butadiene released for release source 1 [kg/site-day]
$Release\_perDay_{RP3}$ = 1,3-Butadiene released for release source 3 [kg/site-day]
$Release\_perDay_{RP4}$ = 1,3-Butadiene released for release source 4 [kg/site-day]

D.2.2 Model Input Parameters

Table_Apx D-2 summarizes the model parameters and their values for the application of adhesives and sealants Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided following this table.

Table_Apx D-2. Summary of Parameter Values and Distributions Used in the Application of Adhesives and Sealants OES

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower Bound	Upper Bound	Mode	Distribution Type	
Container Residue Loss Fraction	$F_{residue}$	kg/kg	0.003	0.0003	0.006	0.003	Triangular	See Appendix D.2.12
Saturation Factor	F_{sat}	unitless	0.5	0.5	1.45	0.5	Triangular	See Appendix D.2.10
Container Volume	V_{cont}	gal/container	55	20	100	55	Triangular	See Appendix D.2.11
Maximum Number of Sites	Ns_{max}	sites	905,620	–	–	–	–	See Appendix D.2.5
PV	PV_{total}	kg/year	3,547,092	153,768	3,547,092	–	Uniform	See Appendix D.2.3
Adhesive/Sealant 1,3-Butadiene Concentration	$F_{1,3\text{-}BD}$	kg/kg	0.24	0.001	0.24	–	Uniform	See Appendix D.2.8
Annual Facility Throughput of Adhesive/Sealants	$Q_{product\_yr}$	kg/site-yr	13,500	1,000	1,000,000	13,500	Triangular	See Appendix D.2.4
Temperature	T	Kelvin	298	–	–	–	–	Process parameter
Pressure	P	torr	760	–	–	–	–	Process parameter
Gas Constant	R	L*torr/(mol*K)	62.36367	–	–	–	–	Universal constant
Vapor Pressure	VP	mmHg	2.11E03	–	–	–	–	Physical property
Density	RHO	kg/L	0.6149	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	54.09	–	–	–	–	Physical property
Fill Rate of Containers	$RATE_{fill\_cont}$	containers/hr	20	–	–	–	–	See Appendix D.2.13
Diameter of Opening for Container Cleaning	$D_{opening\_cont}$	cm	5.08	–	–	–	–	See Appendix D.2.14

D.2.3 Production Volume

EPA estimated the PV for the Application of adhesives and sealants OES using the national production range according 2020 CDR data, an ACC report detailing 1,3-butadiene use a technical report estimating air emissions of 1,3-butadiene (U.S. EPA, 2020a, 1996) (EPA-HQ-OPPT-2018-0451-0041). The ACC report provided conversion rates for several end formulation product types including, but not limited to, styrene-butadiene rubber, adiponitrile, and neoprene rubber. The EPA published technical report provided a percentage breakdown of 1,3-butadiene use within each formulation product type for specific end use categories, including adhesives and sealants. EPA used the conversion rate and end use percentages with the 2020 CDR PV range to estimate the PV for use within the application of adhesives and sealants OES. Table_Apx D-3 provides the PV estimation for the application of adhesives and sealants.

Table_Apx D-3. Production Volume Estimation for Application of Adhesives and Sealants OES

Formulation Product Type	Formulation Product Percentage of Production Volume (%)	Adhesive and Sealant Use Rate (%)	Formulation Product Conversion Rate	Production Volume (lb)	Rationale
2020 CDR 1,3 Butadiene Production Volume Range			1,000,000,000 to 5,000,000,000 lb		
Styrene-Butadiene Rubber	30	3	0.999	9,000–45,000	According to ACC, the butadiene monomer is recovered and recycled during the manufacturing process. It is assumed that only 0.001% of the butadiene used in the SBR manufacturing process is present as residual in the final product (EPA-HQ-OPPT-2018-0451-0041).
Polybutadiene	20	N/A – no adhesive and sealant use	N/A	N/A	No adhesive and sealant use expected using this polymer.
Adiponitrile	15	n/a – no adhesive and sealant use	N/A	N/A	No adhesive and sealant use expected using this polymer.
Styrene-Butadiene Latex	10	N/A – no adhesive and sealant use	N/A	N/A	No adhesive and sealant use expected using this polymer.
Neoprene Rubber	5	12	0.95	300,000 to 1,500,000	According to the EPA published technical report, the conversion rate of 1,3-butadiene in the Chloroprene/Neoprene manufacturing process is 95%. (U.S. EPA, 1996)
ABS Resin	5	N/A – no adhesive and sealant use	N/A	N/A	No adhesive and sealant use expected using this polymer.
Nitrile Rubber	5	10	0.999	5,000 to 25,000	According to the EPA published technical report, the conversion rate of 1,3-butadiene in the

Formulation Product Type	Formulation Product Percentage of Production Volume (%)	Adhesive and Sealant Use Rate (%)	Formulation Product Conversion Rate	Production Volume (lb)	Rationale
					nitrile rubber manufacturing process ranges from 75–90%. However, the source also indicates that unreacted monomer is reacted and recycled into the manufacturing stream. Assume that a maximum of 0.001% 1,3-butadiene is residual in the product stream (U.S. EPA, 1996).
Miscellaneous	10	25	0.95 to 0.999	25,000 to 6,250,000	SBS and SEBS polymers are assumed to fall under the miscellaneous polymer use category. 1,3-Butadiene conversion was estimated by taking the reported range of all other polymer conversion percentages used in PV estimation (U.S. EPA, 1996).
Production Volume Range for Application of Adhesives and Sealants OES			339,000 to 7,820,000 lb 153,768 to 3,547,092 kg		

D.2.4 Throughput Parameters

The annual throughput of adhesive and sealant product is modeled using a triangular distribution with a lower bound of 1,000 kg/yr, an upper bound of 1,000,000 kg/yr, and mode of 13,500 kg/yr. This is based on the ESD on the Use of Adhesives (OECD, 2013). The ESD provides default adhesive use rates based on end-use category. EPA compiled the end-use categories that were relevant to downstream uses for adhesives and sealants containing 1,3-butadiene, which included general assembly, motor and non-motor vehicles, vehicle parts, tire manufacturing (except retreading), and computer/electronic and electrical product manufacturing. The lower and upper bound adhesive use rates for these categories was 1,000 to 1,000,000 kg/yr. The mode is based on the ESD default for unknown end-use markets.

The annual throughput of 1,3-butadiene in adhesives/sealants is calculated using Equation_Apx D-5 by multiplying the annual throughput of all adhesives and sealants by the concentration of 1,3-butadiene in the adhesives or sealants.

Equation_Apx D-5.

$$Q_{1,3\text{-}BD\_year} = Q_{product\_yr} * F_{1,3\text{-}BD}$$

Where:

$Q_{1,3\text{-}BD\_year}$ = Facility annual throughput of 1,3-butadiene [kg/site-yr]
$Q_{product\_yr}$ = Facility annual throughput of all adhesives/sealants [kg/batch]
$F_{1,3\text{-}BD}$ = Concentration of 1,3-butadiene in adhesives/sealants (Appendix D.2.8) [kg/kg]

The daily throughput of 1,3-butadiene is calculated using Equation_Apx D-6 by dividing the annual PV by the number of operating days. The number of operating days is determined according to Appendix D.2.9.

Equation_Apx D-6.

$$Q_{1,3-BD\_day} = \frac{Q_{1,3-BD\_year}}{OD}$$

Where:

$Q_{1,3\text{-}BD\_day}$	=	Facility daily throughput of 1,3-butadiene [kg/site-day]
$Q_{1,3\text{-}BD\_year}$	=	Facility annual throughput of 1,3-butadiene [kg/site-yr]
OD	=	Operating days (Appendix D.2.9) [days/yr]

D.2.5 Number of Sites

For the NAICS codes identified in the Emission Scenario Document on the Use of Adhesives there are 905,620 adhesive and sealants application sites (OECD, 2015a). Therefore, this value is used as a bounding limit, not to be exceeded by the calculation. Number of sites is calculated using the following equation:

Equation_Apx D-7.

$$N_s = \frac{PV}{Q_{1,3-BD\_yr}}$$

Where:

N_s	=	Number of sites [sites]
PV	=	Production volume (see Section D.2.3) [kg/year]
$Q_{1,3-BD-year}$	=	Facility annual throughput of 1,3-butadiene (see Section D.2.4) [kg/site-yr]

D.2.6 Number of Containers per Year

The number of 1,3-butadiene raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation_Apx D-8.

$$N_{cont\_unload\_yr} = \frac{Q_{1,3-BD\_year}}{V_{cont} * \frac{3.79L}{gal} * RHO}$$

Where:

$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded [container/site-year]
$Q_{1,3\text{-}BD\_year}$	=	Facility annual throughput of 1,3-butadiene (Appendix D.2.4) [kg/site-yr]
RHO	=	1,3-Butadiene density [kg/L]
V_{cont}	=	Container volume (Appendix D.2.11) [gal/container]

D.2.7 Operating Hours

EPA estimated operating hours or hours of release duration using data provided from the ESD on Use of Adhesives (OECD, 2015b), ChemSTEER User Guide (U.S. EPA, 2013), and/or through calculation from other parameters.

For container unloading (release point 3), the operating hours are calculated based on the number of

containers unloaded at the site and the unloading rate using the following equation:

Equation_Apx D-9.

$$OH_{RP3} = \frac{N_{cont\_unload\_yr}}{RATE_{fill} * OD}$$

Where:

OH_{RP3}	=	Operating time for release point 3 [hrs/site-day]
$N_{cont\_unload\_yr}$	=	Annual number of containers unloaded (Appendix D.2.6) [container/site-year]
$RATE_{fill}$	=	Container fill rate (Appendix D.2.13) [containers/hr]
OD	=	Operating days (Appendix D.2.9) [days/site-year]

D.2.8 Adhesive and Sealant 1,3-Butadiene Concentration

EPA determined 1,3-butadiene concentrations in adhesive/sealant products ($F_{1,3\text{-}BD}$) using compiled SDS information. EPA did not have information on the prevalence or market share of different adhesive/ sealant products in commerce; therefore, EPA developed a uniform distribution of 1,3-butadiene concentrations using a lower bound of 0.1 percent and an upper bound of 24 percent.

D.2.9 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower bound of 50 days/yr, an upper bound of 365 days/yr, and a mode of 260 days/yr. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 50 to 365 days/yr. This is based on the ESD on Use of Adhesives (OECD, 2013). The ESD provides operating days for several end-use categories, as listed in Appendix D.2.4. The range of operating days for the end-use categories is 50 to 365 days/yr. The mode of the distribution is based on the ESD's default of 260 days/yr for unknown or general use cases.

D.2.10 Saturation Factor

The 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, 2013).

D.2.11 Container Size

Due to a lack of readily available 1,3-butadiene adhesive and sealant product volumes, EPA assumed default container size ranges for drums identified in the ChemSTEER User Guide. Drums were chosen as the product size to represent the possibility of commercial use sites that use large volume of adhesive and sealant products, and to prevent an unreasonable estimated number of containers unloaded per day. Specifically, EPA used a lower bound of 20 gallons, an upper bound of 100 gallons based on the upper bound, and a mode of 55 gallons defined by the ChemSTEER User Guide (U.S. EPA, 2013).

D.2.12 Container Loss Fractions

For drums, EPA paired the data from the PEI Associates Inc. study (PEI Associates, 1988) such that the

residuals data for emptying drums by pouring was aligned with the default central tendency and high-end values from the EPA/OPPT Drum Residual Model. For unloading drums by pouring in the PEI Associates Inc. study (PEI Associates, 1988), EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.03 to 0.79 percent and an average of 0.32 percent. The EPA/OPPT Drum Residual Model from the ChemSTEER User Guide (U.S. EPA, 2013) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for drums is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the EPA/OPPT Drum Residual Model in the ChemSTEER User Guide (U.S. EPA, 2013). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (PEI Associates, 1988) for emptying drums by pouring.

D.2.13 Container Fill Rate

The ChemSTEER User Guide (U.S. EPA, 2013) provides a typical fill rate of 20 containers per hour for containers ranging from 20 to 1,000 gallons of liquid.

D.2.14 Diameter of Opening

For container cleaning activities, the ChemSTEER User Guide indicates a single default value of 5.08 cm for containers less than 5,000 gallons (U.S. EPA, 2013).

Appendix E 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 personal protective equipment (PPE). The hierarchy of controls prioritizes the most effective measures first which 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, including protection factors for various respirators. 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 protection factors on EPA's occupational exposure estimates can be explored in *Draft Risk Calculator for Occupational Exposures for 1,3-Butadiene (*U.S. EPA, 2024i*).*

E.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 E-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 E-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 E-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 the U.S. Department of Labor's 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 U.S. 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)

- Non-powered air purifying respirators are most common, 94 percent overall and varying from 89 percent 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 E-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 E-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

Appendix F MAPPING FACILITIES FROM STANDARD ENGINEERING SOURCES TO OCCUPATIONAL EXPOSURE SCENARIOS AND CONDITIONS OF USE

F.1 Conditions of Use and Occupational Exposure Scenarios

Condition of Use (COU)

TSCA section3(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". COUs included in the scope of EPA's risk evaluations are typically tabulated in scope documents and risk evaluation documents as summaries of life cycle stages, categories, and subcategories of use, as shown in Table_Apx F-1. Therefore, a COU is defined as a combination of life cycle stage, category, and subcategory. EPA identifies COUs for chemicals during the scoping phase; this process is not discussed in this document.

Occupational Exposure Scenario (OES)

Thus far, EPA has not adopted a standardized definition for OES. The purpose of an OES is to group or segment COUs for assessment of releases and exposures based on similarity of the operations and data availability for each COU. For example, EPA may assess a group of multiple COUs together as one OES due to similarities in release and exposure potential (e.g., the COUs for formulation of paints, formulation of cleaning solutions, and formulation of other products may be assessed together as a single OES). Alternatively, EPA may assess multiple OES for one COU because there are different release and exposure potentials for a given COU (e.g., the COU for batch vapor degreasing may be assessed as separate OES for open-top vapor degreasing and closed-loop vapor degreasing). OES determinations are also 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. This is depicted in Figure_Apx F-1.

For chemicals undergoing risk evaluation, ERG/EPA maps each industrial and commercial COU to one or more OES based on reasonably available data and information (e.g., CDR, use reports, process information, public and stakeholder comments), assumptions, and inferences that describe how release and exposure take place within a COU. ERG/EPA identify OES for COUs, not vice-versa (i.e., COUs are not altered during OES mapping). The mapping of COUs to OES is separate from and occurs after the identification of COUs. Both the identification of COUs and subsequent mapping of COUs to OES occur early in the risk evaluation process and are not in scope of this document. This section is intended to just provide background context on COUs and OES.

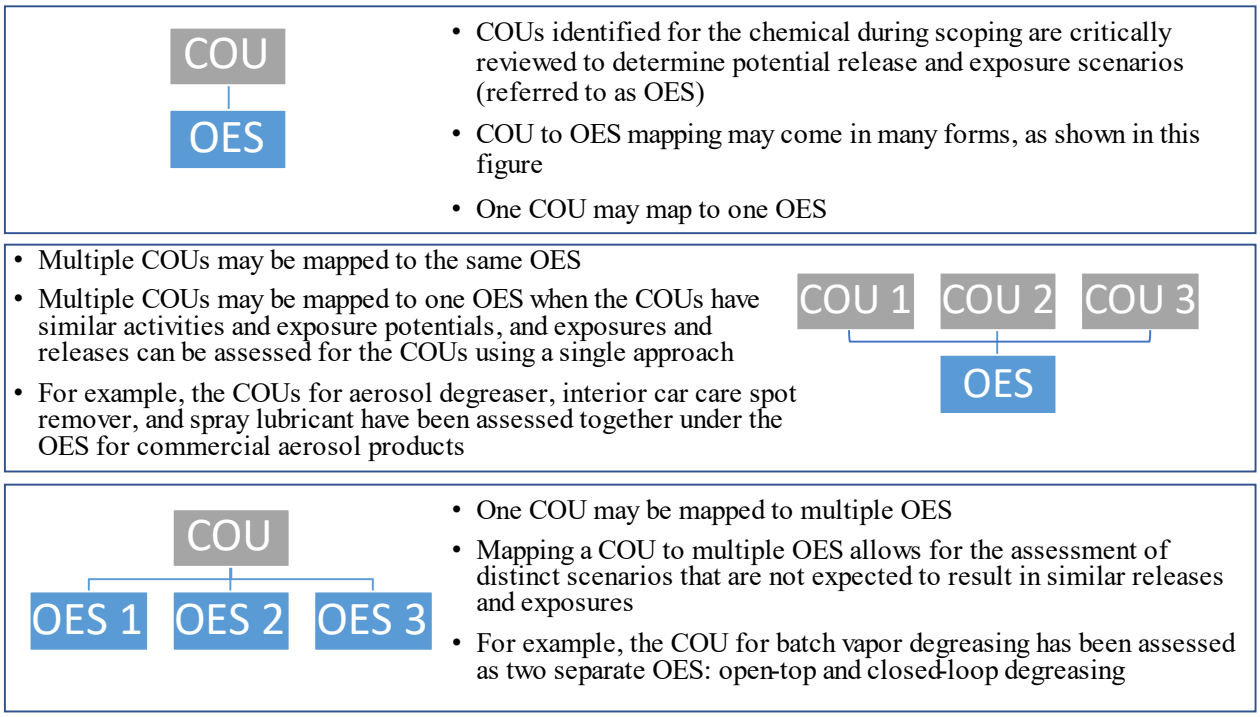
Table_Apx F-1. Example Condition of Use Table with Mapped Occupational Exposure Scenarios

Condition of Use (COU)			Occupational Exposure Scenario (OES)
Life Cycle Stage	**Category[a]**	**Subcategory**	
Manufacturing	Domestic Manufacturing	Domestic Manufacturing	Manufacturing
	Import	Import	Repackaging

Condition of Use (COU)			Occupational Exposure Scenario (OES)
Life Cycle Stage	**Category[a]**	**Subcategory**	
Processing	As a reactant	Intermediate in all other basic organic chemical manufacturing	Processing as a Reactant
	Processing—Incorporation into formulation, mixture, or reaction product	Solvents (for cleaning or degreasing)	Formulation
		Adhesives and sealant chemicals	
	Repackaging	Solvents (for cleaning or degreasing)	Repackaging
	Etc.		

[a] Categories reflect CDR codes and broadly represent the industrial and/or commercial settings of the COU.
[b] The subcategories reflect more specific COUs.

4706



4707
4708 **Figure_Apx F-1. Conditions of Use to Occupational Exposure Scenario Mapping Options**
4709

4710 ## F.2 Standard Sources Requiring Facility Mapping

4711 EPA utilizes release data from EPA programmatic databases and exposure data from standard sources to

complete occupational exposure and environmental release assessments, which are described below:

- Chemical Data Reporting (CDR), to which import and manufacturing sites producing the chemical at or above a specified threshold must report. EPA uses CDR to identify COUs, OES, sites that import or manufacture the chemical, and for information on physical form and concentration of the chemical. In addition, EPA is currently developing the Tiered Data Reporting (TDR) rule, which will establish reporting requirements, including changes to CDR, to collect information that better meets data needs for the TSCA existing chemical program. The rule will have reporting requirements tiered to specific stages of existing chemical assessments (e.g., prioritization, risk evaluation) and harmonized to the Organization for Economic Co-operation and Development (OECD) risk assessment framework, which will help to better inform uses of chemicals and improve upon the OES mapping procedures in this document.

- Toxics Release Inventory (TRI), to which facilities handling a chemical covered by the TRI program at or above a specified threshold must report. EPA uses TRI data to quantify air, water, and land releases of the chemical undergoing risk evaluation.

- National Emissions Inventory (NEI), a compilation of air emissions of criteria pollutants, criteria precursors and hazardous air pollutants from point and non-point source air emissions. EPA uses NEI data to quantify air emissions of the chemical undergoing risk evaluation.

- Discharge Monitoring Report (DMR), a periodic report required of National Pollutant Discharge Elimination System (NPDES) permitted facilities discharging to surface waters. EPA uses NEI data to quantify surface water discharges of the chemical undergoing risk evaluation.

- Occupational Safety and Health Administration (OSHA): Chemical Exposure Health Data (CEHD), a compilation of industrial hygiene samples taken when OSHA monitors worker exposures to chemical hazards. EPA uses OSHA CEHD to quantify occupational inhalation exposures to the chemical undergoing risk evaluation.

- National Institute of Occupational Safety and Health (NIOSH): Health Hazard Evaluations (HHEs), a compilation of voluntary employee, union, or employer requested evaluations of health hazards present at given workplace. EPA uses NIOSH HHE data to quantify occupational inhalation exposures to the chemical undergoing risk evaluation.

To utilize the data from these sources, the facilities that report to each must first be mapped to an OES. There may be other sources of data for specific facilities that require mapping the facilities to an OES; however, this document covers the most common data sources. Additionally, EPA often uses data from sources such as public and stakeholder comments, generic scenarios, and process data that are usually not specific to an individual site; therefore, unlike the above sources, they do not involve the mapping of specific sites to an OES. Therefore, they are not discussed further in this document.

Mapping procedures for the above sources are discussed in detail in the subsequent sections; however, Table_Apx F-2 includes a summary of the type of information reported by companies in each database that helps to inform OES and COU mapping. This includes industrial classification codes such as those associated with the North American Industry Classification System (NAICS) and Standard Industrial Classification (SIC) system. Note that the U.S. government replaced SIC codes with NAICS codes in 1997; however, SIC codes are still used in DMR and are applicable for data from all listed sources for years prior to 1997. Additionally, some of the sources in Table_Apx F-2 have specific reporting

requirements that include flags for the type of processes that occur at the site.

Assessors should be sure that a facility that reports to multiple databases/sources is consistently mapped to the same OES, as applicable. This is not applicable if the facility reports separately for different areas/processes of their facility (*e.g.,* a large chemical plant may report one block of unit operations separate from another such that they have different OES).

Table_Apx F-2. EPA Programmatic Database Information that Aids OES/COU Mapping

Source	Reported Information Useful for Mapping OES/COU	Reporting Frequency	Notes
CDR	- Indication if the chemical is imported or domestically manufactured - Indication if the chemical is imported but never at the site, used on-site, or exported	- Facilities must report to CDR every four years - New data sets take years to become publicly available - Latest reporting year with available data: 2020	- While CDR also includes information on downstream processing and use, it does not include site identities for these operations; thus, it does not inform reporting site OES/COU mapping. - Claims of confidential business information (CBI) can limit data utility in risk evaluations.
TRI	- NAICS codes - Flags for uses and subuses of the chemical - Release media information	- Facilities must report to TRI annually - New data sets become publicly available in October for the previous year - Latest reporting year with available data: 2021	- Reporters must select from specific uses (*e.g.*, manufacture, import, processing) and subuses (*e.g.*, formulation additive, degreaser, lubricant). - Subuse information is only available in data sets starting in 2018. - Facilities may report with a Form A under certain circumstances; [a] Form A's do not require use/subuse reporting.
NEI	- Source Classification Codes (SCCs), which classify different types of activities that generate air emissions - Emissions Inventory System (EIS) Sectors, which classify industry sectors - NAICS codes - Process description free-text field (used for additional information about the process related to the emission unit) - Emission unit description free-text field	- Facilities must report to TRI every three years - New data sets take years to become publicly available. - Latest reporting year with available date: 2020	- NEI contains specific SCC codes and industry sectors from which reporters select. - Free-text fields are not mandatory for the reporter to fill out.

Source	Reported Information Useful for Mapping OES/COU	Reporting Frequency	Notes
DMR	- SIC codes - National Pollutant Discharge Elimination System (NPDES) permit numbers	- Facilities must report to DMR at the frequency specified in their NPDES permit, which is typically monthly - Data typically flows through the State DMR reporting platform to EPA's Enforcement and Compliance History Online (ECHO) database continuously	- Sites that only report non-detection of the chemical for the year are generally excluded from mapping. - NPDES permit numbers can sometimes indicate the type of general permit, which can inform mapping (*e.g.*, remediation general permit).
OSHA	- NAICS or SIC codes	- OSHA conducts monitoring as-needed for site investigations - Monitoring data is available in CEHD when the investigation and any subsequent litigation cases are closed - Latest year in CEHD with data: 2021	- CEHD includes data from 1984 and forward.
NIOSH HHE	- Facility process information - Worker activities	- NIOSH conducts HHEs upon request - HHEs are published online when NIOSH is completed with the evaluation - Latest year with a published HHE: 2023	- NIOSH HHEs generally include narrative descriptions of facility processes and worker activities, with specific information on how the chemical being monitored for is used.
[a] Facilities may report using a Form A if the annual reportable release amount of the chemical did not exceed 500 pounds for the reporting year, and the amounts manufactured, or processed, or otherwise used did not exceed 1 million pounds for that year.			

F.3 OES Mapping Procedures

This section contains procedures for mapping facilities to OES for each source discussed in Section F.2.

F.3.1 Chemical Data Reporting (CDR

The only facilities required to report to CDR are those that manufacture or import specific chemicals at or above a specified threshold.[9] Therefore, sites that report for the chemical of interest in CDR will generally be mapped to either the manufacturing or import/repackaging OES. These sites must also

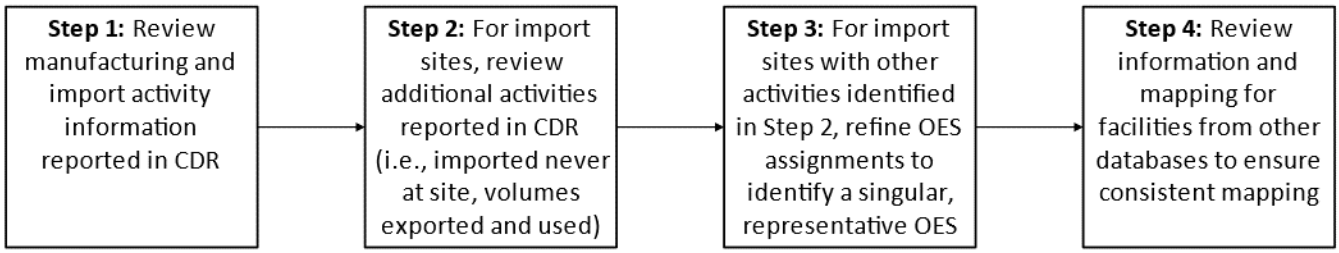
[9] The 2020 CDR reporting instructions, including descriptions on the information required to be reported, can be found at: https://www.epa.gov/chemical-data-reporting/instructions-reporting-2020-tsca-chemical-data-reporting.

report the processing and uses of the chemical; however, these procedures are specific to mapping of the reporting site and not downstream processing or use sites.

CDR, under TSCA, requires manufacturers (including importers) to provide EPA with information on the production and use of chemicals in commerce. These facilities must report to CDR every four years. For risk evaluations conducted under the amended TSCA, EPA has primarily used 2016 and 2020 CDR. The procedures in this document are appliable to both 2016 and 2020 CDR data; however, there are some data elements that are only applicable to 2020 CDR, which are called out in the procedures where appliable. These procedures should be applicable to future CDR, depending on changes to reporting requirements. When the TDR rule is implemented, these procedures will be updated accordingly.

Chemical data reported under CDR is classified using Industrial Function Category (IFC) codes and/or commercial/consumer use product categories (PCs). CDR IFC codes describe the "intended physical or chemical characteristics for which a chemical substance or mixture is consumed as a reactant; incorporated into a formulation, mixture, reaction product, or article, repackaged; or used." Alternatively, PCs describe the consumer and commercial products in which each reportable chemical is used. EPA typically uses these CDR codes to identify the COUs for the chemical in the published scope documents.

Figure_Apx F-2 depicts the steps that should be followed to map CDR reporting sites to OES. Each step is explained in the text below the figure. Additionally, Appendix F.5.1 shows step-by-step examples for using the mapping procedures to determine the OES for three example CDR reporting facilities.



Figure_Apx F-2. OES Mapping Procedures for CDR

To map sites reporting to CDR, the following procedures should be used with the non-CBI CDR:

1. Review Manufacturing and Import Activity Information: The first step in the process is to review the reported activity information to identify if the facility imports or manufactures the chemical.
    a. If the facility reports domestic manufacturing, the manufacturing OES should be assigned, even if the facility also reports importation or the facility may conduct other operations with the chemical. This is because manufacturing of the chemical is expected to be the primary operation, with any other processing or uses being ancillary operations.
    b. If the chemical is being manufactured as a byproduct (this is a voluntary reporting element starting in 2020 CDR), this may need to be considered separately from non-byproduct manufacturing depending on assessment needs for the chemical.
    c. If the facility does not manufacture the chemical and only imports the chemical, check if additional processes occur at the site as described in the subsequent steps.
2. For Importation Sites, Review Fields for "Imported Never at Site", "Volume Exported", and

"Volume Used": The next step is to review these additional fields to determine if the reporting facility conducts more than just importation activities.

a. If the facility imports the chemical, they must report if it is imported but never physically at the reporting site. If the facility indicates the chemical is imported and never at site, the facility does not handle the chemical and the only applicable OES is importation. In such cases, the assessor should proceed to Step 4. If the facility does not indicate the chemical is imported and never at site, proceed to Step 2.b.

b. If the facility reports a quantity for "volume exported" and this quantity is the same as that imported, no additional OES occurs at the site beyond importation. In such cases, the assessor should proceed to Step 4. If the exported quantity is not equal to volume imported, assessors should check if any of the chemical is used at the reporting site per Step 2.c.

c. If the facility reports a quantity for "volume used", additional OES may be applicable to the facility beyond manufacturing or importation. Proceed to Step 3 to identify and refine additional OES.

3. Refine OES Assignments: If multiple OES were identified from the previous steps, a single primary OES must be selected using additional facility information. OES determinations should be made with the following considerations:

a. 6-digit NAICS code reported by the facility in CDR. Note that this is only a requirement starting in 2020 CDR (*e.g.,* for a facility that reported NAICS code was 325520, Adhesive Manufacturing, the incorporation into a formulation, mixture, or reaction product OES may be appropriate; for a facility reporting a NAICS code starting in 424690, Other Chemical and Allied Products Merchant Wholesalers, only the repackaging OES is likely applicable).

b. Downstream processing and use information reported in CDR. The reporting site must provide information on downstream processing and use of the chemical for all sites, meaning it cannot be distinguished which processing and use information includes the reporting site operations vs. downstream site operations. However, this information may still help inform the operations at the reporting site and should be reviewed. Specifically, for a given processing/use activity, if the submitter reports "Fewer than 10 sites" for the "number of sites" field (which is the lowest number of sites that can be reported), there is a likelihood that the facility's operations may be included in this processing/use activity. In such cases, review the corresponding fields for "type of processing or use operation", "industrial sector", and "function category" to help identify the OES. The greater number of sites that are reported, the more likely that the associated processing and use information includes information from downstream sites and the less reliable the information is for mapping OES to the reporting site.

c. Internet research of the types of products made at the facility (*e.g.,* if a facility's website indicates the facility manufactures plastic products, the chemical may be used as a processing aid or component in the plastic products, depending on the known uses of the chemical within the plastics industry).

d. Information from other reporting databases as described in Step 3.

e. An evaluation of the OES that is most likely to result in a release (*e.g.,* for facilities that reported importation and may also conduct formulation per the reported NAICS code, the formulation OES may be assigned, because, in most cases, importation would have a

lower likelihood of a release).

f. Grouped OES for similar uses (*e.g.*, multiple facilities that may conduct formulation operations based on the reported NAICS code may be assigned a grouped formulation OES that covers all types of formulation [*e.g.*, adhesives, paints, cleaning products]).

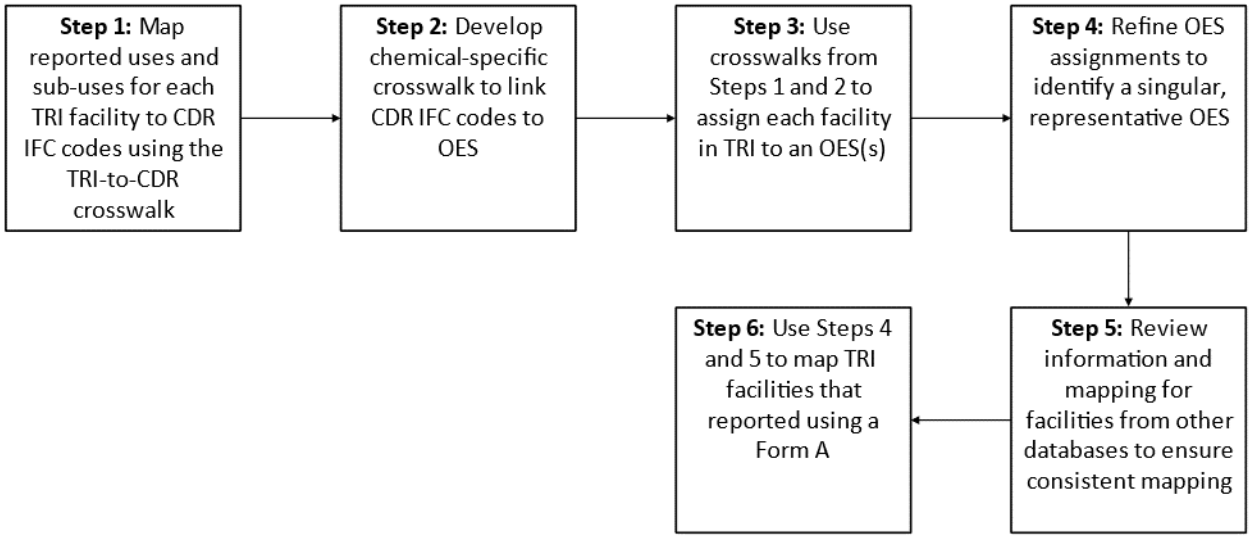
4. Review Information from Other Databases: Other databases/sources (such as TRI, NEI, and DMR) should be checked to see if the facility has reported to these. If so, the OES determined from the mapping procedures for those databases (discussed in other sections of this document) should also be used. It is important that the same facility is mapped consistently across multiple databases/sources. The facility's TRI identification number (TRFID) and Facility Registry Services identification number (FRS ID) can be used to identify sites that report to TRI, DMR, and NEI. If the facility does not report to these databases, but additional OES are possible per Step 2, the assessor should search available facility information on the internet.

Given the information available in CDR, ERG/EPA expects that, for most chemicals, 100 percent of the sites reporting to CDR can feasibly be mapped to an OES.

F.3.2 Toxics Release Inventory (TRI)

TRI reporting is required for facilities that manufacture (including import), process, or otherwise use any TRI-listed chemical in quantities greater than the established threshold in the calendar year AND have 10 or more full-time employee equivalents (*i.e.*, a total of 20,000 hours or greater) and are included in a covered NAICS code. Therefore, unlike CDR reporters that are primarily manufacturers and importers, TRI reporters can be mapped to a variety of different OES.

Figure_Apx F-3 depicts the steps that should be followed to map TRI reporting sites to OES. Each step is explained in the text below the figure. Additionally, Appendix F.5.2 shows step-by-step examples for using the mapping procedures to determine the OES for three example TRI reporting facilities.



Figure_Apx F-3. OES Mapping Procedures for TRI

To map sites reporting to TRI, the following procedures should be used:

1. Assign Chemical Data Reporting Codes using TRI-to-CDR Crosswalk: The first step in the TRI mapping process is to map the uses and sub-uses reported by each facility to one or more 2016

CDR IFC codes. To do this, first compile all TRI uses/sub-uses for the reporting facility into a single column, then map them to CDR IFC codes using the TRI-to-CDR Use Mapping crosswalk (see Appendix B). This is a universal crosswalk that applies to all chemicals.

2. Develop Chemical-Specific Crosswalk to Link CDR Codes to OES: The next step is to develop a separate CDR IFC code-to-OES crosswalk that links CDR IFC codes to OES for the chemical. To create this crosswalk, match the COU categories and subcategories from the COU table in the published scope documents (like the example provided in Table 1-1) to the list of 2016 CDR IFC codes in the CDR reporting instructions.[10] The categories and subcategories of COUs typically match the IFC code category. Recent examples of already completed CDR IFC code-to-OES crosswalk can be found for the fenceline chemicals (1-bromopropane, methylene chloride, n-Methylpyrrolidone, carbon tetrachloride, perchloroethylene, trichloroethylene, and 1,4-dioxane).
3. Assign OES: Each TRI facility is then mapped to one or more OES using the CDR IFC codes assigned to each facility in Step 1 and the CDR IFC code-to-OES crosswalk developed in Step 2.
4. Refine OES Assignments: If a facility maps to more than one OES in Step 3, a single primary OES must be selected using additional facility information. OES determinations should be made with the following considerations:
    a. 6-digit NAICS codes reported by the facility in TRI (*e.g.*, for a facility that reported TRI uses for both formulation and use as cleaner, EPA assigned the formulation OES if the NAICS code was 325199, All Other Basic Organic Chemical Manufacturing; another example is NAICS codes 562211, Hazardous Waste Treatment and Disposal, and 327310, Cement Manufacturing, almost always correspond to the disposal OES, regardless of the reported TRI uses and sub-uses).
    b. Internet research of the types of products made at the facility (*e.g.*, if a facility's website indicates the facility manufactures metal parts, the facility is likely to use chemicals for degreasing or in a metalworking fluid) and information from sources cited in the COU table and scoping document, such as public and stakeholder comments (*i.e.*, EPA/ERG will review sources cited in the COU table and scoping document to see if there is any information specific to the reporting site that can be used to inform the mapping).
    c. Information from other reporting databases as described in Step 5.
    d. An evaluation of the OES that is most likely to result in a release (*e.g.*, facilities that reported both importation and formulation may be assigned a formulation OES, because, in most cases, importation would have a lower likelihood of a release).
    e. Grouped OES for similar uses/sub-uses (*e.g.*, facilities that reported cleaner and degreaser sub-uses may be assigned a grouped OES that covers both cleaning and degreasing because the specific cleaning/degreasing operation cannot be determined from the TRI data).
5. Review Information from Other Databases: Other databases/sources (including CDR, NEI, and DMR) should be checked to see if the facility has reported to these. If so, the OES determined from the mapping procedures for those databases (discussed in other sections of this document) should also be used. It is important that the same facility is mapped consistently across multiple databases/sources. The facility's TRFID and FRS ID can be used to identify sites that report to TRI, DMR, and NEI.

[10] IFC codes and their definitions can be found in Table 4-11 of the CDR reporting instructions: https://www.epa.gov/chemical-data-reporting/instructions-reporting-2016-tsca-chemical-data-reporting

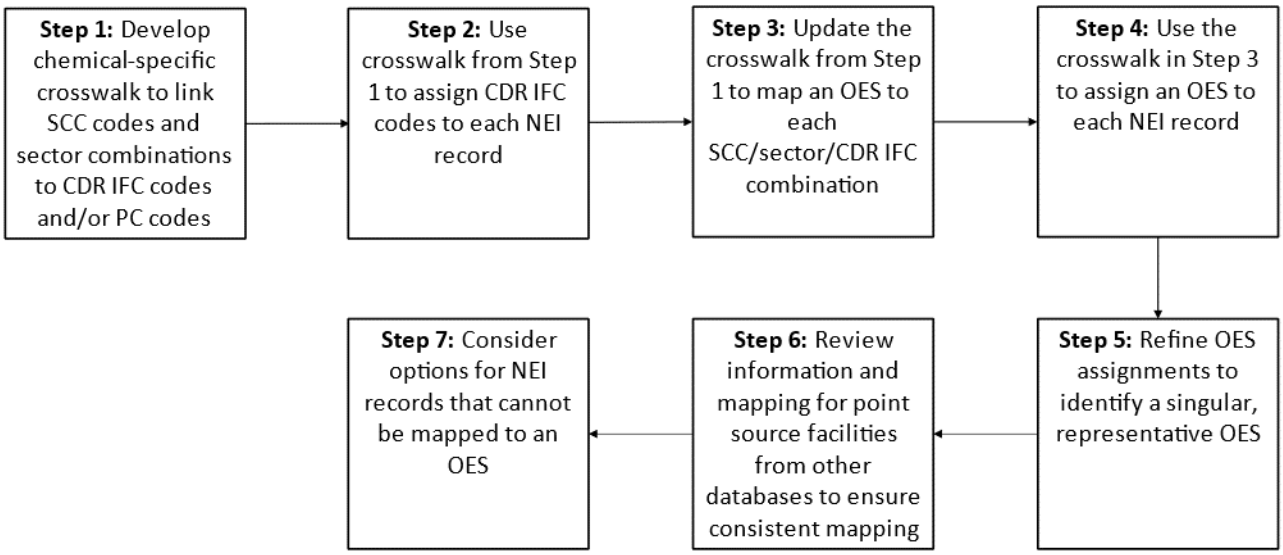
6. Note that facilities that submit using a TRI Form A do not report TRI uses/sub-uses. To determine the OES for these facilities, EPA will use information from Steps 4 and 5.

Given the information available in TRI, ERG/EPA expects that, for most chemicals, 100 percent of the sites reporting to TRI can feasibly be mapped to an OES.

F.3.3 National Emissions Inventory (NEI)

The NEI is a compilation of air emissions of criteria pollutants, criteria precursors, and hazardous air pollutants from point and non-point source air emissions. Air emissions data for the NEI are collected at the state, local, and tribal (SLT) level. The Air Emissions Reporting Requirement rule requires SLT air agencies to collect, compile, and submit criteria pollutant air emissions data to EPA. Many SLT air agencies also voluntarily submit data for pollutants on EPA's list of hazardous air pollutants. Major sources are required to report point source emissions data to their SLT air agency. Each SLT entity must, in turn, report point source emissions data to EPA every one to three years, depending upon the size of the source. Nonpoint estimates are typically developed by state personnel.

Figure_Apx F-4 depicts the steps that should be followed to map NEI reporting sites/records to OES. Each step is explained in the text below the figure. Additionally, Section F.5.3 shows step-by-step examples for using the mapping procedures to determine the OES for one point source example and one nonpoint source example.



Figure_Apx F-4. OES Mapping Procedures for NEI

To map sites reporting point source emissions and nonpoint emissions records for the chemical of interest to NEI, the following procedures should be used:

1. Develop Crosswalks to Link NEI-Reported SCC and Sector Combinations to Chemical Data Reporting Codes: The first step in mapping NEI data to potentially relevant OES is to develop a crosswalk to map each unique combination of NEI-reported Source Classification Code (SCC) (levels 1-4) and industry sectors to one or more CDR codes. This crosswalk is developed on a chemical-by-chemical basis rather than an overall crosswalk for all chemicals because SCCs correspond to emission sources rather than chemical uses such that the crosswalk to CDR codes

may differ from chemical to chemical. In some cases, it may not be possible to assign all SCC sector combinations to CDR codes, in which case information from Step 5 can be used to help make OES assignments. Separate crosswalks are needed for point and nonpoint source records, as discussed below.

a. For the point source NEI data, the crosswalk should map each unique combination of NEI-reported SCC and industry sectors to one or more CDR IFC codes.

b. For nonpoint source NEI data, the crosswalk should link the SCC codes and sectors to both CDR IFC codes and/or commercial/consumer use PCs. This is because the nonpoint source data may include commercial operations, for which CDR PCs may be more appropriate.

2. Use CDR Crosswalks to Assign CDR Codes: Next, the chemical-specific CDR crosswalk developed in Step 1 should be used to assign CDR IFC codes to each point source NEI record and CDR IFC codes and/or commercial/consumer use PCs to each nonpoint source NEI record.

3. Update CDR Crosswalks to Link CDR Codes to OES: The chemical-specific crosswalk developed in Step 1 is then used to link the SCCs, sectors, and CDR codes in the crosswalk to an OES. The OES will be assigned based on the chemical specific COU categories and subcategories and the OES mapped to them as discussed in Appendix F.1.

4. Use CDR Crosswalks to Assign OES: The chemical-specific CDR crosswalks developed in Steps 1-3 are then used to assign OES to each point source and nonpoint source NEI data record (*i.e.*, each combination of facility-SCC-sector). Note that the individual facilities in the point source data set may have multiple emission sources, described by different SCC and sector combinations within NEI, such that multiple OES map to these NEI records. In such cases, a single, representative OES must be selected for each NEI record using the additional information described in Step 5. Similarly, the sectors reported by nonpoint sources may map to multiple CDR IFC or PC codes, such that multiple OES are applicable and must be refined to a single OES for each NEI record.

5. Refine OES Assignments: The initial OES assignments may need to be confirmed and/or refined to identify a single primary OES using the following information described below for point source and nonpoint source records.

a. For point source records in NEI, use the following information to refine OES assignments:

- Additional information available in NEI:
  - Facility name.
  - Primary NAICS code and description, populated from the EIS lookup tables.
  - Facility site description, which, when populated, is intended to describe the type of industry the facility operates (similar to a NAICS description).
  - Process description, which is a free-text field where reporters can provide additional information about the process related to their emission unit.
  - Emission unit description, which is a free-text field where reporters can provide additional information about their emission units.
- Internet research of the types of products made at the facility (*e.g.*, if a facility's

website indicates the facility manufactures metal parts, the facility is likely to use chemicals for degreasing or in a metalworking fluid) and information from sources cited in the COU table and scoping document, such as public and stakeholder comments (*i.e.*, EPA/ERG will review sources cited in the COU table and scoping document to see if there is any information specific to the reporting site that can be used to inform the mapping).

- Information from other reporting databases as described in Step 5.b.
- An evaluation of the OES that is most likely to result in a release (*e.g.*, facilities that map to both lubricant use and vapor degreasing may be assigned a vapor degreasing OES, because, in most cases, vapor degreasing results in higher air emissions).
- Grouped OES for similar uses/sub-uses (*e.g.*, facilities that map to both general cleaning and vapor degreasing may be assigned a grouped OES that covers both cleaning and degreasing because the specific cleaning/degreasing operation cannot be determined from the NEI data).

b. For nonpoint source records in NEI, use the following information to refine OES assignments (there is no additional data reported to NEI by nonpoint sources that can help refine the OES mapping):

- General knowledge about the use of the chemical in the reported sector, such as from scope documents, public or stakeholder comments, process descriptions, professional judgement, or already-identified sources from systematic review.
- Internet research of the uses of the chemical in the reported sector, if insufficient information is not already available per the previous bullet.
- An evaluation of the OES that is most likely to result in a release (*e.g.*, sectors that map to both lubricant use and vapor degreasing may be assigned a vapor degreasing OES, because, in most cases, vapor degreasing results in higher air emissions).
- Grouped OES for similar uses/sub-uses (*e.g.*, sectors that map to both general cleaning and vapor degreasing may be assigned a grouped OES that covers both cleaning and degreasing because the specific cleaning/degreasing operation cannot be determined from the NEI data).

6. Review Information from Other Databases for Point Source Facilities: Other databases/sources (including CDR, TRI, and DMR) should be checked to see if the point source facilities have reported to these. If so, the OES determined from the mapping procedures for those databases (discussed in other sections of this document) should also be used. It is important that the same facility is mapped consistently across multiple databases/sources. The facility's TRFID and FRS ID can be used to identify sites that report to TRI, DMR, and NEI.

7. Consider Options for NEI Records that Cannot be Mapped to an OES: Given the number of records in NEI and the information available, it may not always be feasible to achieve mapping of 100% of the sites reporting to NEI to an OES. For example, there may be NEI records for restaurants or the commercial cooking sector, which do not map to an in-scope COU or OES. Additionally, NEI records may include emissions from combustion byproducts for the chemical, which does not correspond to a COU or OES. In such cases, multiple options may be appropriate depending on assessment needs, such as:

a. Assigning the sites as having an unknown OES with 250 release days/year. This allows for subsequent exposure modeling and the assessment of risk. For sites with identified risk, the OES can then be mapped using the below resources.

b. Contacting the facility for clarification on the use of the chemical. ICR requirements also apply when contacting 10 or more facilities. Note that information requests such as these may require an Information Collection Request (ICR) if 10 or more entities are contacted.[11]

F.3.4 Discharge Monitoring Report (DMR)

Facilities must submit DMRs for chemicals when the following two conditions are met: (1) the facility has an NPDES permit for direct discharges to surface water, and (2) the NPDES permit contains monitoring requirements for the chemical of interest. Indirect discharges (*e.g.*, those sent to an off-site wastewater treatment plant or publicly owned treatment works) are not covered under the NPDES program.

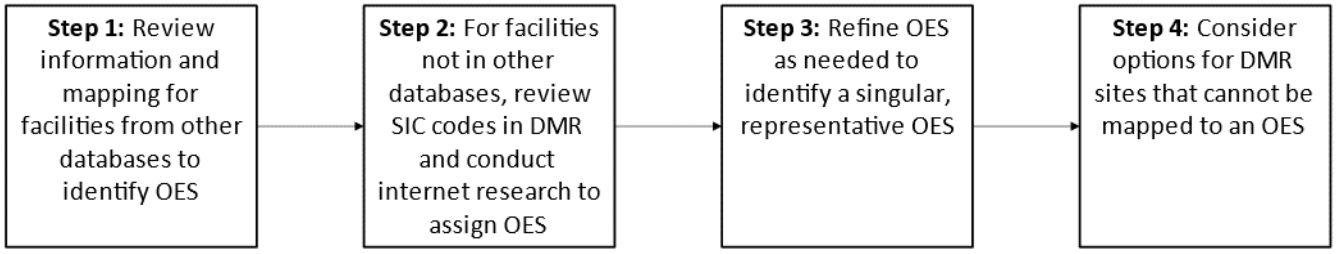
If a facility has discharge monitoring requirements for the chemical of interest, these requirements are either technology-based or water-quality based. Typically, a facility has NPDES monitoring requirements for a chemical because the facility somehow manufactures, processes, or uses the chemical. However, it is possible for a facility to have monitoring requirements for a chemical they do not handle if the facility falls within a guideline containing requirements for that chemical, as described below.

- Technology-based guidelines: If the facility falls within a certain industrial sector, it may be covered by a national effluent guideline. Effluent guidelines are industry-specific and contain treatment technology-based guidelines for discharges of specified pollutants (chemicals) commonly found within that industry.[12] A common effluent guideline containing requirements for chemicals that have or are currently undergoing risk evaluation is the Organic Chemicals, Plastics & Synthetic Fibers (OCPSF) effluent guideline. Alternatively, if there is no applicable effluent guideline for the facility, the permitting authority may establish technology-based guidelines using best professional judgment. If a facility falls within an existing effluent guideline, the permitting authority will generally include monitoring requirements in the facility's NPDES permit that are consistent with the effluent guideline, even if the facility does not handle all the chemicals for which there are monitoring requirements. Therefore, under this reasoning, it is possible that a facility reporting for the chemical of interest in DMRs does not actually handle the chemical.[13]

- Water quality-based guidelines: The receiving water for the facility's discharges is impaired such that the permitting authority sets general water-quality based effluent limits and monitoring requirements for chemicals that may further impair the water quality. It is possible that the permitting authority uses these same general water-quality based requirements for all facilities that discharge to the water body. Therefore, under this reasoning, it is possible that a facility reporting for the chemical of interest in DMRs does not actually handle the chemical.

[11] More on Information Collection Requests can be found at: https://www.epa.gov/icr/icr-basics
[12] A list of the industries for which EPA has promulgated effluent guidelines is available at: https://www.epa.gov/eg/industrial-effluent-guidelines#existing
[13] Note that a facility may request to have monitoring requirements reduced or removed from the permit where historical sampling demonstrates that these chemicals are consistently measured below the effluent limits. Thus, it is possible for a facility to cease monitoring for the chemical of interest upon approval by the permitting authority.

Figure_Apx F-5 depicts the steps that should be followed to map DMR reporting sites to OES. Each step is explained in the text below the figure. Additionally, Appendix F.5.4 shows step-by-step examples for using the mapping procedures to determine the OES for two example DMR reporting facilities.



Figure_Apx F-5. OES Mapping Procedures for DMR

To map sites reporting to DMR, the following procedures should be used:

1. Review Information from Other Databases: Given the limited facility information reported in DMRs, the first step for mapping facilities reporting to DMR should be to check other databases/sources (including CDR, TRI, and NEI). If so, the OES determined from the mapping procedures for those databases (discussed in other sections of this document) should be used. It is important that the same facility is mapped consistently across multiple databases/sources. The facility's TRFID and FRS ID can be used to identify sites that report to TRI, DMR, and NEI.
2. Assign OES: If the facility does not report to other databases, the following information should be used to assign an OES.
    a. 4-digit SIC codes reported by the facility in DMR (*e.g.*, a facility that reported SIC code 2891, Adhesives and Sealants, likely formulates these products; a facility that reported SIC code 4952, Sewerage Systems, likely treats wastewater). Note that SIC codes can be crosswalked to NAICS codes, which are often more useful for mapping OES because they are more descriptive than SIC codes.
    b. Internet research of the types of products made at the facility (*e.g.*, if a facility's website indicates the facility manufactures metal parts, the facility is likely to use chemicals for degreasing or in a metalworking fluid) and information from sources cited in the COU table and scoping document, such as public and stakeholder comments (*i.e.*, EPA/ERG will review sources cited in the COU table and scoping document to see if there is any information specific to the reporting site that can be used to inform the mapping).
3. Refine OES: If the specific OES still cannot be determined using the information in Step 2, the following should be considered.
    a. NPDES permit numbers reported in DMR. The permit number generally indicates if the permit is an individual permit or a general permit.[14] If the permit is a general permit, the permit number can often indicate the type of general permit, which can provide information on the operations at the facility.
        - Individual NPDES permits are numbered in the format of the state abbreviation followed by a seven-digit number (*e.g.*, VA0123456). General permits are usually numbered in the format of state abbreviation followed by one letter then a six-

[14] Information on individual and general NPDES permits can be found at: https://www.epa.gov/npdes/npdes-permit-basics

digit number (*e.g.*, VAG112345 or MAG912345).

- Since each state is slightly different in their general permit numbering, the general permit number should be searched on the internet to determine the type of general permit. For the general permit number examples provided above, a permit number beginning in "VAG11" signifies Virginia's general permit for concrete products facilities and a permit number beginning with "MAG91" signifies Massachusetts' general permit for groundwater remediation. Other common general permit types include those for construction sites, mining operations, sites that only discharge non-contact cooling water, and vehicle washes

b. Searching for the permit online. If the specific NPDES permit for the facility can be found online, it may contain some general process information for the facility that can help inform the OES mapping. However, NPDES permits may be difficult to find online and do not generally contain much information on process operations.

c. An evaluation of the OES that is most likely to result in a water release (*e.g.*, for facilities that report an SIC code for the production of metal products, both vapor degreasing and metalworking fluid OES are applicable; in such cases, the metalworking fluid OES may be assigned because it is more likely to result in water releases than vapor degreasing).

d. Grouped OES for similar uses (*e.g.*, multiple facilities that may conduct formulation operations based on the reported SIC code may be assigned a grouped formulation OES that covers all types of formulation [*e.g.*, adhesives, paints, cleaning products]).

4. Consider Options for DMR Sites that Cannot be Mapped to an OES: Given the limited information available in DMR, it may not always be feasible to achieve mapping of 100 percent of the sites reporting to DMR to an OES. In such cases, multiple options may be appropriate depending on assessment needs, such as:

a. Assigning the sites as having an unknown OES with 250 release days/year. This allows for subsequent exposure modeling and the assessment of risk. For sites with identified risk, the OES can then be mapped using the below resources.

b. Contacting the state government for the NPDES permit, permit applications, past inspection reports, and any available information on facility operations. Note that information requests such as these may require an ICR if 10 or more entities are contacted.

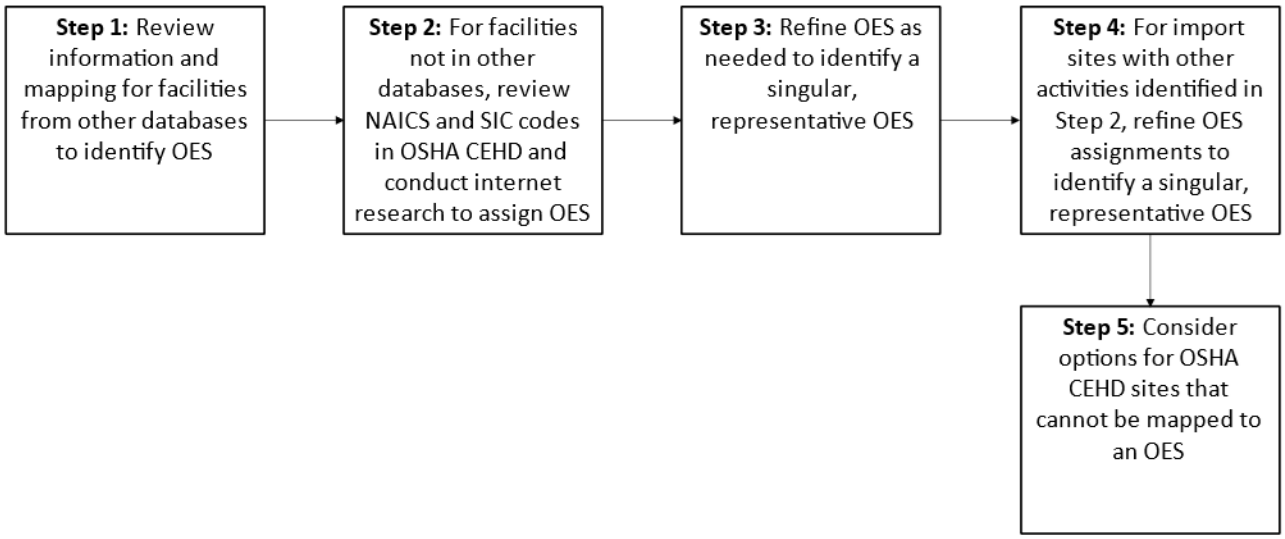
c. Contacting the facility for clarification on the use of the chemical. ICR requirements also apply when contacting 10 or more facilities.

F.3.5 Occupational Safety and Health Administration (OSHA) Chemical and Exposure Data (CEHD)

OSHA CEHD is a compilation of industrial hygiene samples (*i.e.*, occupational exposure data) taken when OSHA monitors worker exposures to chemical hazards. OSHA will conduct monitoring at facilities that fall within targeted industries based on national and regional emphasis programs.[15] OSHA conducts monitoring to compare against occupational health standards. Therefore, unlike CDR, TRI, NEI, and DMR, facilities are not required to report data to OSHA CEHD. Also, OSHA only visits selected facilities, so the amount of OSHA data available for each OES is often limited.

[15] More information on OSHA CEHD can be found at: https://www.osha.gov/opengov/health-samples

Figure_Apx F-6 depicts the steps that should be followed to map OSHA CEHD sites to OES. Each step is explained in the text below the figure. Additionally, Appendix F.5.5 shows step-by-step examples for using the mapping procedures to determine the OES for two example OSHA CEHD facilities.



Figure_Apx F-6. OES Mapping Procedures for OSHA CEHD

Within the OSHA CEHD data, there may be sites for which all air sampling data are non-detect (below the limit of detection) for the chemical. In these cases, if there is also no bulk sampling data indicating the presence of the chemical, there is no evidence that the chemical is present at the site. OSHA may have sampled for the chemical based on a suspicion or pre-determined sampling plan, and not because the chemical was actually present at the site. Therefore, these sites do not need to be mapped to OES. To map sites for which there is OSHA CEHD data that are not all non-detect for the chemical, the following procedures should be used:

1. Review Information from Other Databases: Given the limited facility information reported in OSHA CEHD, the first step for mapping facilities should be to check other databases/sources (including CDR, TRI, NEI, and TRI). If so, the OES determined from the mapping procedures for those databases (discussed in other sections of this document) should be used. It is important that the same facility is mapped consistently across multiple databases/sources. Because facility identifiers such as TRFID and FRS ID are not available in the CEHD, the name of the facility in the CEHD will need to be compared to the facility names in other databases to identify if the facility is present in multiple databases/sources.
2. Assign OES: If the facility does not report to other databases, the following information should be used to assign an OES.
    a. 4-digit SIC and 6-digit NAICS codes reported in the CEHD (*e.g.*, a facility that reported SIC code 2891, Adhesives and Sealants, likely formulates these products; a facility that reported NAICS code 313320, Fabric Coating Mills, likely uses the chemical in fabric coating).
    b. Internet research of the types of products made at the facility (*e.g.*, if a facility's website indicates the facility manufactures metal parts, the facility is likely to use chemicals for degreasing or in a metalworking fluid) and information from sources cited in the COU table and scoping document, such as public and stakeholder comments (*i.e.*, EPA/ERG will review sources cited in the COU table and scoping document to see if there is any

information specific to the reporting site that can be used to inform the mapping).

3. Refine OES: If the specific OES still cannot be determined using the information in Step 2, the following should be considered.
    a. An evaluation of the OES that is most likely to result in occupational exposures (*e.g.,* for facilities that report an SIC code for janitorial services, multiple OES may be applicable, such as cleaning, painting (*e.g.,* touch-ups), other maintenance activities; in such cases, the cleaning OES may be assigned for volatile chemicals because it has the highest exposure potential).
    b. Grouped OES for similar uses (*e.g.,* multiple facilities that may conduct formulation operations based on the reported NAICS or SIC code may be assigned a grouped formulation OES that covers all types of formulation [*e.g.,* adhesives, paints, cleaning products]).
4. Consider Options for OSHA CEHD Sites that Cannot be Mapped to an OES: Given the limited information available in OSHA CEHD, it may not always be feasible to achieve mapping of 100 percent of the sites in the database to an OES. In such cases, multiple options may be appropriate depending on assessment needs, such as:
    a. Assigning the sites as having an unknown OES with 250 exposure days/year. This allows for subsequent health modeling and the assessment of risk. For workers with identified risk, the OES can then be mapped using the below resources.
    b. Contacting OSHA for additional information on the facility from the OSHA inspection/monitoring.
    c. Contacting the facility for clarification on the use of the chemical. Note that information requests such as these may require an ICR if 10 or more entities are contacted.
    d. As discussed previously, sites for which all air monitoring data is non-detect for the chemical and for which there is no bulk data indicating the presence of the chemical do not need to be mapped to an OES. This is because the data do not provide evidence that the chemical is present at the site.

F.3.6 National Institute of Occupational Safety and Health (NIOSH) Health Hazard Evaluation (HHE)

NIOSH conducts HHEs at facilities to evaluate current workplace conditions and to make recommendations to reduce or eliminate the identified hazards.[16] NIOSH conducts HHEs at the request of employers, unions, or employees in workplaces where employee health and wellbeing is affected by the workplace. Therefore, unlike CDR, TRI, NEI, and DMR, facilities are not required to report data to NIOSH under the HHE program. Also, NIOSH only visits selected facilities where an HHE was requested, so the number of NIOSH HHEs available for each OES is often limited.

To map a facility that is the subject of a NIOSH HHE, the information in the HHE report should be used. Specifically, the HHE report typically includes general process information for the facility, information on how the chemical is used, worker activities, and the facility's SIC code. This information should be sufficient to map the facility to a single representative OES. Additionally, given the extent of information available about the subject facilities in NIOSH HHE reports, 100 percent of these facilities can be mapped to an OES. Additionally, Appendix F.5.6 shows two examples of how to map NIOSH

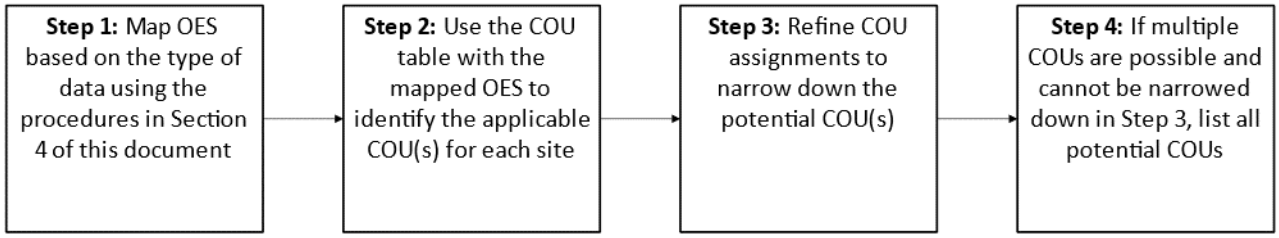
[16] More information about NIOSH HHEs is available at: https://www.cdc.gov/niosh/hhe/about.html

HHE facilities to OES.

F.4 COU Mapping Procedures

As discussed in Appendix F.1, there is not always a one-to-one mapping between COUs and OES.

Figure_Apx F-7 depicts the steps that should be followed to map sites from the standard sources discussed in this document to COUs, using the OES mapping completed in Appendix F.3. Each step is explained in the text below the figure. Additionally, Appendix F.5.7 shows step-by-step examples for using the mapping procedures to determine the COU for three example facilities.



Figure_Apx F-7. COU Mapping Procedures for Standard Sources Already Mapped to OES

To map facilities from standard sources (*i.e.*, CDR, TRI, NEI, DMR, OSHA CEHD, NIOSH HHE) to COUs, the following procedures should be used:

1. Map the Facility to an OES: To map a facility from a standard source to a COU, the facility should first be mapped to an OES following the procedures for the specific source of data (discussed in Appendix F.3).
2. Use the COU Table with Mapped OES to Assign COUs: At the point of the risk evaluation process where EPA/ERG are mapping data from standard sources to OES and COU, EPA/ERG have already mapped OES to each of the COUs from the scope document, as shown in Table 1-1. This crosswalk between COUs and OES should be used to identify the COU(s) for the facility using the OES mapped per Appendix F.3.
3. Refine the COU Assignment: In some instances, more than one COU may map to the facility. In such cases, the following information should be used to try to narrow down the list of potentially applicable COUs:
    a. Information from the standard sources (*e.g.*, if ERG/EPA assigned a grouped OES like "Industrial Processing Aid" and the facility's NAICS code in TRI or NEI is related to battery manufacturing, the COU can be identified as the "Processing Aid" category and "Process solvent used in battery manufacture" subcategory).
    b. Internet research of the types of products made at the facility (*e.g.*, if a facility's website indicates the facility makes adhesives, the COU category of "Processing—Incorporation into formulation, mixture or reaction product" and subcategory of "Adhesives and sealant chemicals" can be assigned and the remaining subcategories [*e.g.*, solvents for cleaning or degreasing, solvents which become part of the product formulation or mixture] are not applicable) and information from sources cited in the COU table and scoping document, such as public and stakeholder comments (*i.e.*, EPA/ERG will review sources cited in the COU table and scoping document to see if there is any information specific to the reporting site that can be used to inform the mapping).
4. List all Potential COUs: Where the above information does not narrow down the list of potentially applicable COUs, EPA/ERG will list all the potential COUs and will not attempt to

select just one from the list where there is insufficient information to do so.

F.5 Example Case Studies

This section contains step-by-step examples of how to implement the OES and COU mapping procedures listed in Appendix Sections F.3 and F.4 to determine OES for facilities that report to standard engineering sources.

F.5.1 CDR Mapping Examples

This section includes examples of how to implement the OES mapping procedures for sites reporting to CDR, as listed in Appendix F.3.1. Specifically, this section includes examples for three example sites that reported to 2020 CDR for the round 2 chemical Di-isononyl phthalate (DINP). These example sites are referred to as Facility A, Facility B, and Facility C.

To map Facilities A, B, and C to an OES, the following procedures are used with the non-CBI 2020 CDR database.

1. Review Manufacturing and Import Activity Information: The first step in the process is to review the reported activity information to identify if the facility imports or manufactures the chemical. Table_Apx F-3 summarizes the information gathered from 2020 CDR for the three example sites for this step.

Table_Apx F-3. Step 1 for CDR Mapping Facilities

Facility Name	Step 1a: Reported Activity	Step 1b: Byproduct Information	Step 1c: Check Other Activities?	OES Determination
Facility A	Domestically Manufactured/Imported	Not known or reasonably ascertainable	Not needed.	Per Step 1a, this site maps to the Manufacturing OES.
Facility B	Imported	CBI	Yes	Cannot be determined in Step 1—Proceed with Step 2.
Facility C	Imported	Not known or reasonably ascertainable	Yes	Cannot be determined in Step 1—Proceed with Step 2.

2. For Importation Sites, Review Fields for "Imported Never at Site", "Volume Exported", and "Volume Used": The next step is to review these additional fields to determine if the reporting facility conducts more than just importation activities. Table_Apx F-4 summarizes the information gathered from 2020 CDR for the three example sites for this step.

Table_Apx F-4. Step 2 for CDR Mapping Example Facilities

Facility Name	Step 2a: Imported Never at Site	Step 2b: Volume Exported	Step 2c: Volume Used	OES Determination
Facility A	n/a: OES determined in Step 1			
Facility B	CBI	CBI	CBI	Cannot be determined in Step 2: Proceed with Step 3.
Facility C	Yes	0	0	Since the facility only imports and does not use DINP, this site maps to the Import/Repackaging OES.

3. Refine OES Assignments: If multiple OES were identified from the previous steps, a single primary OES must be selected using additional facility information as discussed in Steps 3a to 3f. Table_Apx F-5 summarizes the information gathered from 2020 CDR for the three example sites for this step.

Table_Apx F-5. Step 3 for CDR Mapping Example Facilities

Facility Name	Step 3a: NAICS	Step3b: Processing/Use Information	Step 3c: Internet Research	Step 3d–e: Other Databases and OES Grouping	OES Determination
Facility A	n/a: OES determined in Step 1				
Facility B	325110, Petrochemical Manufacturing	CBI	Research indicates the facility is a petrochemical plant and does not indicate how DINP is used.	Check other databases per Step 4.	Cannot be determined in Step 2: Proceed with Step 4.
Facility C	n/a: OES determined in Step 2				

4. Review Information from Other Databases: Lastly, other databases/sources (such as TRI, NEI, and DMR) should be checked to see if the facility has reported to these. If the facility does not report to these databases, but additional OES are possible per Step 2, search available facility information on the internet. Table_Apx F-6 summarizes the information gathered from 2020 CDR for the three example sites for this step.

Table_Apx F-6. Step 4 for CDR Mapping Example Facilities

Facility Name	Step 4: Other Databases	OES Determination
Facility A	n/a: OES determined in Step 1	
Facility B	Using the FRS ID reported in CDR, this facility does not report to TRI, NEI, or DMR. EPA searched the facility in EPA's ECHO database and found that the facility does not have any listed NAICS codes, SIC codes, or permits, and appears to be a warehouse from aerial imagery. Therefore, this facility is likely just an importer.	Using the information from Step 4, this site maps to the Import/Repackaging OES.
Facility C	n/a: OES determined in Step 2	

F.5.2 TRI Mapping Examples

This appendix includes examples of how to implement the OES mapping procedures for sites reporting to TRI, as listed in Appendix F.3.2. Specifically, this appendix includes examples for three example sites that reported to TRI for the round 2 chemical 1,2-dichloroethane (1,2-dichloroethane). These example sites are referred to as Facility D, Facility E, and Facility F.

To map Facilities D, E, and F to an OES, the following procedures are used with information from TRI.

1. Assign Chemical Data Reporting Codes using TRI-to-CDR Crosswalk: The first step in the TRI mapping process is to map the uses and sub-uses reported by each facility to one or more 2016 CDR IFC codes. The uses and sub-uses reported to TRI by each example site are compiled in Table_Apx F-7, along with the 2016 CDR IFC codes mapped using Appendix A.

Table_Apx F-7. Step 1 for TRI Mapping Example Facilities

Facility Name	TRI Form Type	TRI Uses (Sub-uses)	2016 CDR IFC Codes
Facility D	R	Manufacture: produce, import, for onsite use/processing, for sale/distribution, as a byproduct Processing: as a reactant, as a formulation component (P299 Other) Otherwise Used: ancillary or other use (Z399 Other)	PK, U001, U003, U016, U013, U014, U018, U019, U020, U023, U027, U028, or U999
Facility E	R	Otherwise Used: ancillary or other use (Z399 Other)	U001, U013, U014, U018, U020, or U023
Facility F	A	None—not reported in Form A submissions	

2. Develop Chemical-Specific Crosswalk to Link CDR Codes to OES: The next step is to develop a separate CDR IFC code-to-OES crosswalk that links CDR IFC codes to OES for the chemical. To create this crosswalk, match the COU and OES from the COU table in the published scope documents to the list of 2016 CDR IFC codes. The categories and subcategories of COUs typically match the IFC code category. See Table_Apx F-8 for the completed crosswalk for 1,2-dichloroethane.

5340 **Table_Apx F-8. Step 2 for TRI Mapping Example Facilities**

COU and OES from Published Scope Document				Mapping		
Life Cycle Stage	Category	Subcategory	Occupational Exposure Scenario	2016 CDR IFC Code	2016 CDR IFC Code Name	Rationale
Manufacturing	Domestic Manufacturing	Domestic Manufacturing	Manufacturing	None	None	Per Section F.5.1, there is no corresponding CDR code for this COU/OES.
Repackaging	Repackaging	Repackaging	Repackaging	PK	Processing-repackaging	Category matches CDR code
Processing	Processing—As a Reactant	Intermediate in Petrochemical manufacturing	Processing as a reactant	U015; U016; U019; U024	Processing as a reactant	Category matches CDR code
		Plastic material and resin manufacturing				
		All other basic organic chemical manufacturing				
Processing	Processing—Incorporation into formulation, mixture, or reaction product	Fuels and fuel additives: All other petroleum and coal products manufacturing	Incorporated into formulation, mixture, or reaction product	U012	Fuel and fuel additives	Category matches CDR code
		Formulation of Adhesives and Sealants		U002	Adhesives and sealant chemicals	Category matches CDR code
		Processing aids: specific to petroleum production		U025	Processing aids: specific to petroleum production	Category matches CDR code
Distribution in Commerce	Distribution in Commerce	Distribution in Commerce	Distribution in commerce	None	None	Per Section F.5.1, there is no corresponding CDR

COU and OES from Published Scope Document				Mapping		
						code for this COU/OES.
Industrial Use	Adhesives and Sealants	Adhesives and Sealants	Adhesives and sealants	U002	Adhesives and sealant chemicals	Category matches CDR code
	Functional Fluids (Closed Systems)	Engine Coolant Additive	Functional fluids (closed systems)	U013	Functional Fluids (closed systems)	Category matches CDR code
	Lubricants and Greases	Paste lubricants and greases	Lubricants and greases	U017	Lubricants and Lubricant additives	Category matches CDR code
	Oxidizing/Reducing Agents	Oxidation inhibitor in controlled oxidative chemical reactions	Oxidizing/reducing agents	U019	Oxidizing/reducing agents	Category matches CDR code
	Cleaning and Degreasing	Industrial and commercial non-aerosol cleaning/degreasing	Solvents (for cleaning and degreasing)	U029	Solvents (for cleaning or degreasing)	Category matches CDR code
		Vapor Degreasing (TBD)				
Commercial Use	Cleaning and Degreasing	Commercial aerosol products (Aerosol degreasing, aerosol lubricants, automotive care products)				
	Plastic and Rubber Products	Products such as: plastic and rubber products	Plastics and rubber products	None	None	Per Section F.5.1, there is no corresponding CDR code for this COU/OES.
	Fuels and Related Products	Fuels and related products	Fuels and Related Products	U012	Fuels and Fuel Additives	Category matches CDR code

COU and OES from Published Scope Document				Mapping		
	Other use	Laboratory Chemical Embalming agent	Other use	None	Use-non-incorporative activities	This use does not match any other CDR codes and is non-incorporative
Waste Handling, Disposal, Treatment, and Recycling	Waste Handling, Disposal, Treatment, and Recycling	Waste Handling, Disposal, Treatment, and Recycling	Waste Handling, Disposal, Treatment, and Recycling	None	None	Per Section F.5.1, there is no corresponding CDR code for this COU/OES.

3. Assign OES: Each TRI facility is then mapped to one or more OES using the CDR IFC codes assigned to each facility in Step 1 and the CDR IFC code-to-OES crosswalk developed in Step 2. Table_Apx F-9 includes the potential OES for each example facility per this step.

Table_Apx F-9. Step 3 for TRI Mapping Example Facilities

Facility Name	TRI Form Type	2016 CDR IFC Codes	Crosswalked OES	OES Determination
Facility D	R	PK, U001, U003, U016, U013, U014, U018, U019, U020, U023, U027, U028, or U999	Repackaging, Processing as a Reactant, Functional Fluids (Closed Systems), or Oxidizing/ Reducing Agents	Cannot be determined in Step 3: proceed to Step 4.
Facility E	R	U001, U013, U014, U018, U020, or U023	Functional Fluids (Closed Systems)	Since the facility maps to only one OES, the OES is Functional Fluids (Closed Systems).
Facility F	A	None; not reported in Form A submissions		Cannot be determined in Step 3: proceed to Step 4.

4. Refine OES Assignments: If a facility maps to more than one OES in Step 3, a single primary OES must be selected using additional facility information per Steps 4a-e. Table_Apx F-10 summarizes the information gathered for the three example sites for this step.

Table_Apx F-10. Step 4 for TRI Mapping Example Facilities

Facility Name	Step 4a: NAICS Code	Step 4b: Internet Research	Step 4c: Other Databases	Step 4d-e: Most Likely OES or OES Grouping	OES Determination
Facility D	486990, All Other Pipeline Transportation	The facility is a large chemical manufacturing plant.	Check databases per Step 5.	Based on the type of facility, the Processing as a Reactant OES seems the most likely OES from Step 3.	Most likely Processing as a Reactant OES. Check other databases in Step 5 to verify.
Facility E		n/a; OES determined in Step 3			
Facility F	325199, All Other Basic Organic Chemical Manufacturing	The facility is a chemical supplier that does not appear to produce chemicals.	Check databases per Step 5.	Based on the NAICS code and type of facility, the Repackaging OES seems the most likely.	Most likely Repackaging OES. Check other databases in Step 5 to verify.

5. Review Information from Other Databases: Other databases/sources (including CDR, NEI, and DMR) should be checked to see if the facility has reported to these. If so, the OES determined from the mapping procedures for those databases (discussed in other sections of this document) should also be used. It is important that the same facility is mapped consistently across multiple databases/sources. The facility's TRFID and FRS ID can be used to identify sites that report to TRI, DMR, and NEI. Table_Apx F-11 summarizes the information gathered from other databases for the three example sites for this step.

Table_Apx F-11. Step 5 for TRI Mapping Example Facilities

Facility Name	Step 4: Other Databases	OES Determination
Facility D	The facility did not report to 2016 or 2020 CDR. The facility reported to 2020 NEI, reporting emissions of 1,2-dichloroethane from storage tanks and process equipment from chemical manufacturing processes and storage/transfer operations. The facility reported DMRs for the past few years but reported no releases of 1,2-	The NEI information corroborates the most likely OES determined in Step 4d. Therefore, this site maps to the Processing as a Reactant OES.

Facility Name	Step 4: Other Databases	OES Determination
	dichloroethane to DMR.	
Facility E	n/a; OES determined in Step 3	
Facility F	The facility did not report to 2016 or 2020 CDR, 2020 NEI, or the past few years of DMR.	Since no additional information was determined in Step 5, the site maps to the Repackaging OES per Step 4d.

F.5.3 NEI Mapping Examples

This section includes examples of how to implement the OES mapping procedures for sites reporting to NEI, as listed in Appendix F.3.3. Specifically, this section includes two examples for 1,2-dichloroethane from 2017 NEI: (1) Facility G, which is an industrial site that reported point source emissions under multiple NEI records, and (2) Example H, which is a county that reported non-point source emissions under multiple NEI records.

To map Facility G (point source) and Example H (non-point source) NEI records to OES, the following procedures should be used:

1. Develop Crosswalks to Link NEI-Reported SCC and Sector Combinations to Chemical Data Reporting Codes: The first step in mapping NEI data to potentially relevant OES is to develop a crosswalk to map each unique combination of NEI-reported Source Classification Code (SCC) (levels 1-4) and industry sectors to one or more CDR codes. This crosswalk is developed on a chemical-by-chemical basis rather than an overall crosswalk for all chemicals because SCCs correspond to emission sources rather than chemical uses such that the crosswalk to CDR codes may differ from chemical to chemical. In some cases, it may not be possible to assign all SCC sector combinations to CDR codes, in which case information from Step 5 can be used to help make OES assignments. Separate crosswalks are needed for point and nonpoint source records, as shown in Table_Apx F-12 and Table_Apx F-13. Note that these tables only present the crosswalk for the SCC and sector codes relevant to Facility G (point source) and Example H (non-point source) examples; there are many more SCC and sector codes reported for 1,2-dichloroethane in 2017 NEI.

Table_Apx F-12. Step 1a for NEI Mapping Example Facilities

SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Sector	Assigned CDR Code	Rationale
Chemical Evaporation	Organic Solvent Evaporation	Air Stripping Tower	Solvent	Solvent—Industrial Surface	U029: Solvents (for Cleaning and Degreasing)	Based on sector.

SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Sector	Assigned CDR Code	Rationale
				Coating & Solvent Use		
Chemical Evaporation	Organic Solvent Evaporation	Cold Solvent Cleaning/Stripping	Other Not Classified	Solvent—Degreasing	U029: Solvents (for Cleaning and Degreasing)	Based on sector.
Chemical Evaporation	Organic Solvent Evaporation	Dry Cleaning	Other Not Classified	Solvent—Dry Cleaning	U029: Solvents (for Cleaning and Degreasing)	Based on sector.
Chemical Evaporation	Organic Solvent Evaporation	Fugitive Emissions	General	Solvent—Degreasing	U029: Solvents (for Cleaning and Degreasing)	Based on sector.
Chemical Evaporation	Organic Solvent Evaporation	Miscellaneous Volatile Organic Compound Evaporation	Miscellaneous	Solvent—Industrial Surface Coating & Solvent Use	U029: Solvents (for Cleaning and Degreasing)	Based on sector.
Chemical Evaporation	Organic Solvent Evaporation	Solvent Storage	General Processes: Drum Storage—Pure Organic Chemicals	Industrial Processes—Storage and Transfer	n/a: no matching CDR IFC, likely Distribution in Commerce	Matched SCC and Sector code.
Chemical Evaporation	Organic Solvent Evaporation	Solvent Storage	General Processes: Spent Solvent Storage	Industrial Processes—Storage and Transfer	n/a: no matching CDR IFC, likely Distribution in Commerce	Matched SCC and Sector code.
Chemical Evaporation	Organic Solvent Evaporation	Waste Solvent Recovery Operations	Other Not Classified	Solvent—Industrial Surface	n/a: no matching CDR IFC, likely Waste	Matched to SCC level 3 code.

SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Sector	Assigned CDR Code	Rationale
				Coating & Solvent Use	Handling, Disposal and Treatment	
Chemical Evaporation	Organic Solvent Evaporation	Waste Solvent Recovery Operations	Solvent Loading	Industrial Processes—Storage and Transfer	n/a: no matching CDR IFC, likely Waste Handling, Disposal and Treatment	Matched to SCC level 3 code.
Industrial Processes	Photo Equip/Health Care/Labs/Air Condit/SwimPools	Health Care—Crematoriums	Cremation—Animal	Industrial Processes—NEC	U999: Other	Does not fit other CDR code.
Industrial Processes	Photo Equip/Health Care/Labs/Air Condit/SwimPools	Health Care—Crematoriums	Cremation—Human	Industrial Processes—NEC	U999: Other	Does not fit other CDR code.
Industrial Processes	Photo Equip/Health Care/Labs/Air Condit/SwimPools	Health Care—Crematoriums	Crematory Stack—Human and Animal Crematories	Industrial Processes—NEC	U999: Other	Does not fit other CDR code.
Industrial Processes	Photo Equip/Health Care/Labs/Air Condit/SwimPools	Health Care	Miscellaneous Fugitive Emissions	Industrial Processes—NEC	U999: Other	Assume use as a laboratory chemical in the healthcare industry.
Industrial Processes	Photo Equip/Health Care/Labs/Air Condit/SwimPools	Laboratories	Bench Scale Reagents: Research	Industrial Processes—NEC	U999: Other	SCC for laboratories.

SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Sector	Assigned CDR Code	Rationale
Industrial Processes	Photo Equip/Health Care/Labs/Air Condit/SwimPools	Laboratories	Bench Scale Reagents: Testing	Industrial Processes—NEC	U999: Other	SCC for laboratories.

Table_Apx F-13. Step 1b for NEI Mapping Example Facilities

Sector	Assigned CDR Code	Rationale
Commercial Cooking	n/a; no matching CDR IFC	Unknown
Fuel Comb—Comm/Institutional—Biomass	U012: Fuels and fuel additives	Consistent with sector code
Fuel Comb—Comm/Institutional—Coal	U012: Fuels and fuel additives	Consistent with sector code
Fuel Comb—Industrial Boilers, ICEs—Biomass	U012: Fuels and fuel additives	Consistent with sector code
Fuel Comb—Industrial Boilers, ICEs—Coal	U012: Fuels and fuel additives	Consistent with sector code
Fuel Comb—Residential—Other	U012: Fuels and fuel additives	Consistent with sector code
Gas Stations	U012: Fuels and fuel additives	Consistent with sector code
Solvent—Consumer & Commercial Solvent Use	U029: Solvents (for cleaning or degreasing)	Consistent with sector code
Waste Disposal	n/a: no matching CDR IFC, likely Waste Handling, Disposal and Treatment	Consistent with sector code

2. Use CDR Crosswalks to Assign CDR Codes: Next, the chemical-specific CDR crosswalk developed in Step 1 should be used to assign CDR IFC codes to each point source NEI record and CDR IFC codes and/or commercial/consumer use PCs to each nonpoint source NEI record. This is shown in Table_Apx F-14 for Facility G (point source) and Example H (non-point source).

Table_Apx F-14. Step 2 for NEI Mapping Example Facilities

Facility Name	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Sector	Assigned CDR IFC Code
Facility G	Chemical	Organic Solvent	Air Stripping	Solvent	Solvent—Industrial	U029: Solvents (for

Facility Name	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Sector	Assigned CDR IFC Code
	Evaporation	Evaporation	Tower		Surface Coating & Solvent Use	Cleaning and Degreasing)
	Industrial Processes	Photo Equip/Health Care/Labs/Air Condit/SwimPools	Laboratories	Bench Scale Reagents: Testing	Industrial Processes—NEC	U999: Other
Example H	n/a: not applicable to nonpoint source				Commercial Cooking	n/a: no matching CDR IFC
	n/a: not applicable to nonpoint source				Fuel Comb—Residential—Other	U012: Fuels and fuel additives
	n/a: not applicable to nonpoint source				Gas Stations	U012: Fuels and fuel additives

3. Update CDR Crosswalks to Link CDR Codes to OES: The chemical-specific crosswalk developed in Step 1 is then used to link the SCCs, sectors, and CDR codes in the crosswalk to an OES. The OES will be assigned based on the chemical specific COU categories and subcategories and the OES mapped to them. The same crosswalk developed in Table_Apx F-8 (TRI Step 2) links CDR codes to COUs and OES and is used in this example.

4. Use CDR Crosswalks to Assign OES: The chemical-specific CDR crosswalks developed in Steps 1-3 are then used to assign OES to each point source and nonpoint source NEI data record (*i.e.*, each combination of facility-SCC-sector). Note that the individual facilities in the point source data set may have multiple emission sources, described by different SCC and sector combinations within NEI, such that multiple OES map to each NEI record. In such cases, a single, representative OES must be selected for each NEI record using the additional information described in Step 5. Similarly, the sectors reported by nonpoint sources may map to multiple CDR IFC or PC codes, such that multiple OES are applicable and must be refined to a single OES. See Table_Apx F-15 for completed Step 4 for the example facilities.

5400 **Table_Apx F-15. Step 4 for NEI Mapping Example Facilities**

Facility Name	SCC Level One	SCC Level Two	SCC Level Three	SCC Level Four	Sector	Assigned CDR IFC Code	Mapped OES	OES Determination
Facility G	Chemical Evaporation	Organic Solvent Evaporation	Air Stripping Tower	Solvent	Solvent—Industrial Surface Coating & Solvent Use	U029: Solvents (for Cleaning and Degreasing)	Solvents (for cleaning and degreasing)	Since only one OES maps to this NEI record, the OES is Solvents (for cleaning and degreasing)
	Industrial Processes	Photo Equip/Health Care/Labs/Air Condit/SwimPools	Laboratories	Bench Scale Reagents: Testing	Industrial Processes—NEC	U999: Other	Laboratory Chemical Embalming Agent	Cannot be determined in Step 4: Proceed with Step 5.
Example H	n/a: not applicable to nonpoint source				Commercial Cooking	n/a: no matching CDR IFC	None	Cannot be determined in Step 4: Proceed with Step 5.
	n/a: not applicable to nonpoint source				Fuel Comb—Residential—Other	U012: Fuels and fuel additives	Incorporated into Formulation, Mixture, or Reaction Product Fuels and Related Products	Cannot be determined in Step 4: Proceed with Step 5.
	n/a: not applicable to nonpoint source				Gas Stations	U012: Fuels and fuel additives	Incorporated into Formulation, Mixture, or Reaction Product Fuels and Related Products	Cannot be determined in Step 4: Proceed with Step 5.

5. Refine OES Assignments: The initial OES assignments may need to be confirmed and/or refined to identify a single primary OES using the following information described in Steps 5a-b. See Table_Apx F-16 for Facility G (point source) and Example H (non-point source).

Table_Apx F-16. Step 5 for NEI Mapping Example Facilities

Facility Name	Sector	Step 5a: Additional Point Source Information	Step 5b: Additional Non-Point Source Information	OES Determination
Facility G	Solvent—Industrial Surface Coating & Solvent Use	n/a: mapped to OES in Step 4		
	Industrial Processes—NEC	NAICS is 336415, Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing. Emitting process is analytical lab operations.	n/a	Information from Step 4 and 5a affirm the OES is Laboratory Chemical.
Example H	Commercial Cooking	n/a	No knowledge is available on the use of 1,2-dichloroethane in commercial cooking	Cannot be determined in Step 5: Proceed to Step 7.
	Fuel Comb—Residential—Other	n/a	1,2-dichloroethane may be used in fuel additives.	Information from Step 4 and 5a affirm the OES is Fuels and Related Products.
	Gas Stations	n/a	1,2-dichloroethane may be used in fuel additives.	Information from Step 4 and 5a affirm the OES is Fuels and Related Products.

6. Review Information from Other Databases for Point Source Facilities: Other databases/sources (including CDR, TRI, and DMR) should be checked to see if the point source facilities have reported to these. Facility G does not report to other databases. This step is not applicable to non-point source Example H.

7. Consider Options for NEI Records that Cannot be Mapped to an OES: Given the number of records in NEI and the information available, it may not always be feasible to achieve mapping of 100 percent of the sites reporting to NEI to an OES. This is the case for

the NEI record Example H—Commercial Cooking. In this case, the OES will be assessed, per Step 7a, as "unknown OES" with 250 release days/year. This allows for subsequent exposure modeling and the assessment of risk.

F.5.4 DMR Mapping Examples

This section includes examples of how to implement the OES mapping procedures for sites reporting to DMR, as listed in Appendix F.3.4. Specifically, this appendix includes examples for two example sites that reported to DMR for 1,2-dichloroethane. These example sites are referred to as Facility I and J.

To map Facilities I and J to an OES, the following procedures are used with information from DMR:

1. Review Information from Other Databases: Given the limited facility information reported in DMRs, the first step for mapping facilities reporting to DMR should be to check other databases/sources (including CDR, TRI, and NEI). For these examples, neither Facility I nor J reported to other databases.
2. Assign OES: If the facility does not report to other databases, the reported SIC code from DMR and internet research should be used to map the facility to an OES, per Steps 2a and 2b. See Table_Apx F-17 for completed Step 2 for the example facilities.

Table_Apx F-17. Step 2 for DMR Mapping Example Facilities

Facility Name	Step 2a: SIC Code	Step 2b: Internet Research	OES Determination
Facility I	4613, Refined Petroleum Pipeline	Internet research indicates that the facility is a fuel terminal.	Cannot be determined in Step 2: Proceed with Step 3.
Facility J	2821, Plastics Materials and Resins	Internet research indicates the facility makes poly vinyl chloride. 1,2-dichloroethane is known to be used as a reactant in this process.	This facility maps to the Processing as a Reactant OES, based on the SIC code (which matches the subcategory of use in the COU table, Table_Apx F-8) and internet research.

3. Refine OES: If the specific OES still cannot be determined using the information in Step 2, information in Steps 3a-d should be considered. This includes searching for the facility NPDES permit and trying to determine which OES (or group of OES) is the most likely. See Table_Apx F-18 for completed Step 3 for the example facilities.

Table_Apx F-18. Step 3 for DMR Mapping Example Facilities

Facility Name	Step 3a: NPDES Permit Number	Step 3b: Finding the NPDES Permit	Step 3c-d: Most Likely OES or Grouped OED	OES Determination
Facility I	VAG83#### → A search of VA NPDES permits indicates that permit numbers starting in "VAG0083" are remediation general permits.	The facility's NPDES permit could not be found online.	None of COUs or OES for 1,2-dichloroethane in Table_Apx F-8 cover remediation.	Since the facility's permit is for remediation, the facility most likely does not use 1,2-dichloroethane but the chemical is present as a contaminant at the site. This does not correspond to an in-scope OES. However, the OES should be designated as "Remediation" for EPA to determine how/if to present the release data.
Facility J	n/a: This facility was mapped to an OES in Step 2.			

F.5.5 OSHA CEHD Mapping Examples

This section includes examples of how to implement the OES mapping procedures for sites in the OSHA CEHD data set, as listed in Appendix F.3.5. Specifically, this section includes examples for two example sites in the OSHA CEHD data set for 1,4-dioxane. These example sites are referred to as Facility K and L.

To map Facilities K and L to an OES, the following procedures are used with information from OSHA CEHD:

1. Review Information from Other Databases: Given the limited facility information reported in OSHA CEHD, the first step for mapping facilities should be to check other databases/sources (including CDR, TRI, NEI, and TRI). For these examples, neither Facility K nor L reported to other databases.
2. Assign OES: If the facility does not report to other databases, the reported SIC code from OSHA CEHD and internet research should be used to map the facility to an OES, per Steps 2a and 2b. See Table_Apx F-19 for completed Step 2 for the example facilities.

Table_Apx F-19. Step 2 for OSHA CEHD Mapping Example Facilities

Facility Name	Step 2a: SIC or NAICS Code	Step 2b: Internet Research	OES Determination
Facility K	339112, Surgical and Medical Instrument	Internet research indicates that the facility produces medical equipment for	Based on the OES in Table_Apx F-8, the most applicable OES are likely Processing as a Reactant (for the production

Facility Name	Step 2a: SIC or NAICS Code	Step 2b: Internet Research	OES Determination
	Manufacturing	cardiovascular procedures.	of plastics used in equipment), Solvents (for Cleaning or Degreasing), Plastics and Rubber Products, or Other Use. The specific OES cannot be determined in Step 2: Proceed with Step 3.
Facility L	5169, Chemicals and Allied Products, Not Elsewhere Classified	Internet research indicates the facility is a waste management company.	This facility maps to the Waste Handling, Disposal, Treatment, and Recycling, based on information from internet research.

3. Refine OES: If the specific OES still cannot be determined using the information in Step 2, an evaluation of the OES that is most likely or a group of OES should be considered per Steps 3a and 3b. See Table_Apx F-20 for completed Step 3 for the example facilities.

Table_Apx F-20. Step 3 for OSHA CEHD Mapping Example Facilities

Facility Name	Step 3a: Mostly Likely OES	Step 3b: Grouped OED	OES Determination
Facility K	The scope document for 1,2-dichloroethane indicates that the chemical is used to make polyvinyl chloride that is then used in medical devices. The use of 1,2-dichloroethane to produce polyvinyl chloride falls under the Processing as a Reactant OES (as an intermediate for plastics).	Not needed: the OES was determined as Processing as a Reactant in Step 3a.	Per Step 3a, this facility maps to the Processing as a Reactant OES. To further support this determination, EPA may contact OSHA for additional information on the visit to this facility, per Step 4b.
Facility L	n/a: This facility was mapped to an OES in Step 2.		

F.5.6 NIOSH HHE Mapping Examples

This section includes examples of how to implement the OES mapping procedures listed in Appendix F.3.6 for two example NIOSH HHEs for 1,2-dichloroethane. To map facilities that are the subject of a NIOSH HHE, the process information and other narrative descriptions in the NIOSH HHE should be used.

1. The first example is for the following NIOSH HHE: https://www.cdc.gov/niosh/hhe/reports/pdfs/80-186-1149.pdf. The following information is found in the NIOSH HHE:
    a. The facility produces plastic products, primarily plastic tubes for packaging.
    b. 1,2-dichloroethane was used as a bonding agent for sealing packaging.

    OES determination: Based on the OES for 1,2-dichloroethane (listed in Table_Apx F-8), the use of 1,2-dichloroethane for sealants falls under the Adhesives and Sealants OES.
2. The second example is for the following NIOSH HHE: https://www.cdc.gov/niosh/hhe/reports/pdfs/77-73-610.pdf. The following information is found in the NIOSH HHE:
    a. The facility is a chemical manufacturer.
    b. The facility uses 1,2-dichloroethane as a solvent in a reaction to produce another chemical.

    OES determination: Based on the OES for 1,2-dichloroethane (listed in Table_Apx F-8), the use of 1,2-dichloroethane as a reactant falls under the Processing as a Reactant OES.

As discussed in Appendix F.3.6, NIOSH HHEs typically contain detailed process information and description of how the chemical is used at the facility. Therefore, the mapping of NIOSH HHE facilities to OES is straightforward.

F.5.7 COU Mapping Examples

This appendix includes examples of how to implement the COU mapping procedures for sites from standard sources (*i.e.*, CDR, TRI, NEI, DMR, OSHA CEHD, NIOSH HHE, as listed in Appendix F.4. Specifically, this appendix uses the same example facilities (Facility D, Facility E, and Facility F) for the TRI examples in Appendix F.5.2.

To map Facilities D, E, and F to an COUs, the following procedures should be used:

1. Map the Facility to an OES: To map a facility from a standard source to a COU, the facility should first be mapped to an OES following the procedures for the specific source of data (discussed in Appendix F.3). This mapping was completed in completed in Appendix F.5.2 and is summarized in Table_Apx F-21.

Table_Apx F-21. Step 1 for COU Mapping Example Facilities

Facility Name	Step 1: OES Determination from Appendix A.2
Facility D	Processing as a Reactant
Facility E	Functional Fluids (Closed Systems)
Facility F	Repackaging

2. Use the COU Table with Mapped OES to Assign COUs: At the point of the risk evaluation process where EPA/ERG are mapping data from standard sources to OES and COU, EPA/ERG have already mapped OES to each of the COUs from the scope document. This crosswalk between COUs and OES, which is in Table_Apx F-8, for the example facilities should be used to identify the COU(s). See Table_Apx F-22 for completed Step 2 for the example facilities.

Table_Apx F-22. Step 2 for COU Mapping Example Facilities

<table>
<tr><th>Facility Name</th><th>OES Determination from Appendix A.2</th><th>Step 2: Mapped COUs</th></tr>
<tr><td>Facility D</td><td>Processing as a Reactant</td><td>Using the COU to OES crosswalk previously developed (Table_Apx F-8), the COUs that map to this OES are:
<table>
<tr><th>Life Cycle Stage</th><th>Category</th><th>Subcategory</th></tr>
<tr><td rowspan="3">Processing</td><td rowspan="3">Processing—As a Reactant</td><td>Intermediate in Petrochemical manufacturing</td></tr>
<tr><td>Plastic material and resin manufacturing</td></tr>
<tr><td>All other basic organic chemical manufacturing</td></tr>
</table></td></tr>
<tr><td>Facility E</td><td>Functional Fluids (Closed Systems)</td><td>Using the COU to OES crosswalk previously developed (Table_Apx F-8), only one COU maps to this OES:
<table>
<tr><th>Life Cycle Stage</th><th>Category</th><th>Subcategory</th></tr>
<tr><td>Industrial use</td><td>Functional Fluids (Closed Systems)</td><td>Engine Coolant Additive</td></tr>
</table></td></tr>
<tr><td>Facility F</td><td>Repackaging</td><td>Using the COU to OES crosswalk previously developed (Table_Apx F-8), only one COU maps to this OES:
<table>
<tr><th>Life Cycle Stage</th><th>Category</th><th>Subcategory</th></tr>
<tr><td>Repackaging</td><td>Repackaging</td><td>Repackaging</td></tr>
</table></td></tr>
</table>

3. Refine the COU Assignment: In some instances, more than one COU may map to the facility. In such cases, the reported NAICS code and internet research should be used to try to narrow down the list of potentially applicable COUs, per Steps 3a-b. See Table_Apx F-23 for completed Step 3 for the example facilities.

Table_Apx F-23. Step 3 for COU Mapping Example Facilities

Facility Name	Step 3a: NAICS Code	Step 3b: Internet Research	COU Determination
Facility D	486990, All Other Pipeline Transportation	The facility is a large chemical manufacturing plant.	The COU subcategory for "Plastic material and resin manufacturing" can be eliminated. However, the COU cannot be narrowed down between the remaining two subcategories of use. Proceed to Step 4.
Facility E	n/a: COU determined in Step 2		
Facility F	n/a: COU determined in Step 2		

4. List all Potential COUs: Where the above information does not narrow down the list of potentially applicable COUs, EPA/ERG will list all the potential COUs and will not attempt to select just one from the list where there is insufficient information to do so. Since a singular OES was identified for Facility D and F, this step is not applicable to those facilities. For Facility F, there are two possible COUs that are listed in Table_Apx F-24. Since a COU consists of a life cycle stage, category, and subcategory, all three should be presented in this step.

Table_Apx F-24. Step 4 for COU Mapping Example Facilities

Facility Name	Step 4: All Potential COUs
Facility D	All potential COUs for this facility are as follows:

Life Cycle Stage	Category	Subcategory
Processing	Processing—As a Reactant	Intermediate in Petrochemical manufacturing
		All other basic organic chemical manufacturing

F.6 TRI to CDR Use Mapping Crosswalk

Table_Apx F-25presents the TRI-CDR Crosswalk used to map facilities to the OES for each chemical. "N/A" in the 2016 CDR code column indicates there is no corresponding CDR code that matches the TRI code. 2020 CDR introduced new codes for chemicals designated as high priority for risk evaluation; however, reporters may still use the same 2016 CDR codes listed in Table_Apx F-25for all other chemicals. For 2020 CDR reporting facilities using the new codes, the crosswalk between 2016 CDR codes and 2020 CDR codes in Table 4-15 of the 2020 CDR reporting instructions should be used with Table_Apx F-25.

Table_Apx F-25. TRI-CDR Use Code Crosswalk

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
3.1.a	Manufacture: Produce	N/A	N/A	N/A	N/A	N/A
3.1.b	Manufacture: Import	N/A	N/A	N/A	N/A	N/A
3.1.c	Manufacture: For on-site use/processing	N/A	N/A	N/A	N/A	N/A
3.1.d	Manufacture: For sale/distribution	N/A	N/A	N/A	N/A	N/A
3.1.e	Manufacture: As a byproduct	N/A	N/A	N/A	N/A	N/A
3.1.f	Manufacture: As an impurity	N/A	N/A	N/A	N/A	N/A
3.2.a	Processing: As a reactant	N/A	N/A	PC	Processing as a reactant	Chemical substance is used in chemical reactions for the manufacturing of another chemical substance or product.
3.2.a	Processing: As a reactant	P101	Feedstocks	N/A	N/A	N/A
3.2.a	Processing: As a reactant	P102	Raw Materials	N/A	N/A	N/A
3.2.a	Processing: As a reactant	P103	Intermediates	U015	Intermediates	Chemical substances consumed in a reaction to produce other chemical substances for commercial advantage. A residual of the intermediate chemical substance which has no separate function may remain in the reaction product.
3.2.a	Processing: As a reactant	P104	Initiators	U024	Process regulators	Chemical substances used to change the rate of a chemical reaction, start or stop the reaction, or otherwise influence the course of the reaction. Process regulators may be consumed or become part of the reaction product.

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
3.2.a	Processing: As a reactant	P199	Other	U016	Ion exchange agents	Chemical substances, usually in the form of a solid matrix, are used to selectively remove targeted ions from a solution. Examples generally consist of an inert hydrophobic matrix such as styrene divinylbenzene or phenol-formaldehyde, cross-linking polymer such as divinylbenzene, and ionic functional groups including sulfonic, carboxylic or phosphonic acids. This code also includes aluminosilicate zeolites.
3.2.a	Processing: As a reactant	P199	Other	U019	Oxidizing/ reducing agent	Chemical substances used to alter the valence state of another substance by donating or accepting electrons or by the addition or removal of hydrogen to a substance. Examples of oxidizing agents include nitric acid, perchlorates, hexavalent chromium compounds, and peroxydisulfuric acid salts. Examples of reducing agents include hydrazine, sodium thiosulfate, and coke produced from coal.
3.2.a	Processing: As a reactant	P199	Other	U999	Other (specify)	Chemical substances used in a way other than those described by other codes.
3.2.b	Processing: As a formulation component	N/A	N/A	PF	Processing-incorporation into formulation, mixture, or reaction product	Chemical substance is added to a product (or product mixture) prior to further distribution of the product.
3.2.b	Processing: As a formulation component	P201	Additives	U007	Corrosion inhibitors and antiscaling agents	Chemical substances used to prevent or retard corrosion or the formation of scale. Examples include phenylenediamine, chromates, nitrates, phosphates, and hydrazine.
3.2.b	Processing: As a formulation component	P201	Additives	U009	Fillers	Chemical substances used to provide bulk, increase strength, increase hardness, or improve resistance to impact. Fillers incorporated in a matrix reduce production costs by minimizing the amount of more expensive substances used in the production of articles. Examples

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						include calcium carbonate, barium sulfate, silicates, clays, zinc oxide and aluminum oxide.
3.2.b	Processing: As a formulation component	P201	Additives	U010	Finishing agents	Chemical substances used to impart such functions as softening, static proofing, wrinkle resistance, and water repellence. Substances may be applied to textiles, paper, and leather. Examples include quaternary ammonium compounds, ethoxylated amines, and silicone compounds.
3.2.b	Processing: As a formulation component	P201	Additives	U017	Lubricants and lubricant additives	Chemical substances used to reduce friction, heat, or wear between moving parts or adjacent solid surfaces, or that enhance the lubricity of other substances. Examples of lubricants include mineral oils, silicate and phosphate esters, silicone oil, greases, and solid film lubricants such as graphite and PTFE. Examples of lubricant additives include molybdenum disulphide and tungsten disulphide.
3.2.b	Processing: As a formulation component	P201	Additives	U034	Paint additives and coating additives not described by other codes	Chemical substances used in a paint or coating formulation to enhance properties such as water repellence, increased gloss, improved fade resistance, ease of application, foam prevention, etc. Examples of paint additives and coating additives include polyols, amines, vinyl acetate ethylene emulsions, and aliphatic polyisocyanates.
3.2.b	Processing: As a formulation component	P202	Dyes	U008	Dyes	Chemical substances used to impart color to other materials or mixtures (*i.e.*, substrates) by penetrating the surface of the substrate. Example types include azo, anthraquinone, amino azo, aniline, eosin, stilbene, acid, basic or cationic, reactive, dispersive, and natural dyes.
3.2.b	Processing: As a formulation component	P202	Dyes	U021	Pigments	Chemical substances used to impart color to other materials or mixtures (*i.e.*, substrates) by attaching themselves to the surface of the substrate through binding or adhesion.

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						This code includes fluorescent agents, luminescent agents, whitening agents, pearlizing agents, and opacifiers. Examples include metallic oxides of iron, titanium, zinc, cobalt, and chromium; metal powder suspensions; lead chromates; vegetable and animal products; and synthetic organic pigments.
3.2.b	Processing: As a formulation component	P203	Reaction Diluents	U030	Solvents (which become part of product formulation or mixture)	Chemical substances used to dissolve another substance (solute) to form a uniformly dispersed mixture (solution) at the molecular level. Examples include diluents used to reduce the concentration of an active material to achieve a specified effect and low gravity materials added to reduce cost.
3.2.b	Processing: As a formulation component	P203	Reaction Diluents	U032	Viscosity adjustors	Chemical substances used to alter the viscosity of another substance. Examples include viscosity index (VI) improvers, pour point depressants, and thickeners.
3.2.b	Processing: As a formulation component	P204	Initiators	U024	Process regulators	Chemical substances used to change the rate of a chemical reaction, start, or stop the reaction, or otherwise influence the course of the reaction. Process regulators may be consumed or become part of the reaction product.
3.2.b	Processing: As a formulation component	P205	Solvents	U030	Solvents (which become part of product formulation or mixture)	Chemical substances used to dissolve another substance (solute) to form a uniformly dispersed mixture (solution) at the molecular level. Examples include diluents used to reduce the concentration of an active material to achieve a specified effect and low gravity materials added to reduce cost.
3.2.b	Processing: As a formulation component	P206	Inhibitors	U024	Process regulators	Chemical substances used to change the rate of a chemical reaction, start, or stop the reaction, or otherwise influence the course of the reaction. Process regulators may be consumed or become part of the reaction product.
3.2.b	Processing: As a	P207	Emulsifiers	U003	Adsorbents and absorbents	Chemical substances used to retain other substances by accumulation on

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
	formulation component					their surface or by assimilation. Examples of adsorbents include silica gel, activated alumina, and activated carbon. Examples of absorbents include straw oil, alkaline solutions, and kerosene.
3.2.b	Processing: As a formulation component	P208	Surfactants	U002	Adhesives and sealant chemicals	Chemical substances used to promote bonding between other substances, promote adhesion of surfaces, or prevent seepage of moisture or air. Examples include epoxides, isocyanates, acrylamides, phenol, urea, melamine, and formaldehyde.
3.2.b	Processing: As a formulation component	P208	Surfactants	U023	Plating agents and surface treating agents	Chemical substances applied to metal, plastic, or other surfaces to alter physical or chemical properties of the surface. Examples include metal surface treating agents, strippers, etchants, rust and tarnish removers, and descaling agents.
3.2.b	Processing: As a formulation component	P208	Surfactants	U031	Surface active agents	Chemical substances used to modify surface tension when dissolved in water or water solutions or reduce interfacial tension between two liquids or between a liquid and a solid or between liquid and air. Examples include carboxylates, sulfonates, phosphates, carboxylic acid, esters, and quaternary ammonium salts.
3.2.b	Processing: As a formulation component	P209	Lubricants	U017	Lubricants and lubricant additives	Chemical substances used to reduce friction, heat, or wear between moving parts or adjacent solid surfaces, or that enhance the lubricity of other substances. Examples of lubricants include mineral oils, silicate and phosphate esters, silicone oil, greases, and solid film lubricants such as graphite and PTFE. Examples of lubricant additives include molybdenum disulphide and tungsten disulphide.
3.2.b	Processing: As a formulation component	P210	Flame Retardants	U011	Flame retardants	Chemical substances used on the surface of or incorporated into combustible materials to reduce or eliminate their tendency to ignite when exposed to heat or a flame for a

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						short period of time. Examples include inorganic salts, chlorinated, or brominated organic compounds, and organic phosphates/phosphonates.
3.2.b	Processing: As a formulation component	P211	Rheological Modifiers	U022	Plasticizers	Chemical substances used in plastics, cement, concrete, wallboard, clay bodies, or other materials to increase their plasticity or fluidity. Examples include phthalates, trimellitates, adipates, maleates, and lignosulphonates.
3.2.b	Processing: As a formulation component	P211	Rheological Modifiers	U032	Viscosity adjustors	Chemical substances used to alter the viscosity of another substance. Examples include VI improvers, pour point depressants, and thickeners.
3.2.b	Processing: As a formulation component	P299	Other	U003	Adsorbents and absorbents	Chemical substances used to retain other substances by accumulation on their surface or by assimilation. Examples of adsorbents include silica gel, activated alumina, and activated carbon. Examples of absorbents include straw oil, alkaline solutions, and kerosene.
3.2.b	Processing: As a formulation component	P299	Other	U016	Ion exchange agents	Chemical substances, usually in the form of a solid matrix, are used to selectively remove targeted ions from a solution. Examples generally consist of an inert hydrophobic matrix such as styrene divinylbenzene or phenol-formaldehyde, cross-linking polymer such as divinylbenzene, and ionic functional groups including sulfonic, carboxylic or phosphonic acids. This code also includes aluminosilicate zeolites.
3.2.b	Processing: As a formulation component	P299	Other	U018	Odor agents	Chemical substances used to control odors, remove odors, mask odors, or impart odors. Examples include benzenoids, terpenes and terpenoids, musk chemicals, aliphatic aldehydes, aliphatic cyanides, and mercaptans.
3.2.b	Processing: As a formulation component	P299	Other	U019	Oxidizing/ reducing agent	Chemical substances used to alter the valence state of another substance by donating or accepting electrons or by the addition or removal of hydrogen to a substance. Examples of oxidizing

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						agents include nitric acid, perchlorates, hexavalent chromium compounds, and peroxydisulfuric acid salts. Examples of reducing agents include hydrazine, sodium thiosulfate, and coke produced from coal.
3.2.b	Processing: As a formulation component	P299	Other	U020	Photosensitive chemicals	Chemical substances used for their ability to alter their physical or chemical structure through absorption of light, resulting in the emission of light, dissociation, discoloration, or other chemical reactions. Examples include sensitizers, fluorescents, photovoltaic agents, ultraviolet absorbers, and ultraviolet stabilizers.
3.2.b	Processing: As a formulation component	P299	Other	U027	Propellants and blowing agents	Chemical substances used to dissolve or suspend other substances and either to expel those substances from a container in the form of an aerosol or to impart a cellular structure to plastics, rubber, or 219hermos set resins. Examples include compressed gasses and liquids and substances which release ammonia, carbon dioxide, or nitrogen.
3.2.b	Processing: As a formulation component	P299	Other	U028	Solid separation agents	Chemical substances used to promote the separation of suspended solids from a liquid. Examples include flotation aids, flocculants, coagulants, dewatering aids, and drainage aids.
3.2.b	Processing: As a formulation component	P299	Other	U999	Other (specify)	Chemical substances used in a way other than those described by other codes.
3.2.c	Processing: As an article component	N/A	N/A	PA	Processing-incorporation into article	Chemical substance becomes an integral component of an article distributed for industrial, trade, or consumer use.
3.2.c	Processing: As an article component	N/A	N/A	U008	Dyes	Chemical substances used to impart color to other materials or mixtures (*i.e.*, substrates) by penetrating the surface of the substrate. Example types include azo, anthraquinone, amino azo, aniline, eosin, stilbene, acid, basic or cationic, reactive, dispersive, and natural dyes.

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
3.2.c	Processing: As an article component	N/A	N/A	U009	Fillers	Chemical substances used to provide bulk, increase strength, increase hardness, or improve resistance to impact. Fillers incorporated in a matrix reduce production costs by minimizing the amount of more expensive substances used in the production of articles. Examples include calcium carbonate, barium sulfate, silicates, clays, zinc oxide and aluminum oxide.
3.2.c	Processing: As an article component	N/A	N/A	U021	Pigments	Chemical substances used to impart color to other materials or mixtures (*i.e.*, substrates) by attaching themselves to the surface of the substrate through binding or adhesion. This code includes fluorescent agents, luminescent agents, whitening agents, pearlizing agents, and opacifiers. Examples include metallic oxides of iron, titanium, zinc, cobalt, and chromium; metal powder suspensions; lead chromates; vegetable and animal products; and synthetic organic pigments.
3.2.c	Processing: As an article component	N/A	N/A	U034	Paint additives and coating additives not described by other codes	Chemical substances used in a paint or coating formulation to enhance properties such as water repellence, increased gloss, improved fade resistance, ease of application, foam prevention, etc. Examples of paint additives and coating additives include polyols, amines, vinyl acetate ethylene emulsions, and aliphatic polyisocyanates.
3.2.c	Processing: As an article component	N/A	N/A	U999	Other (specify)	Chemical substances used in a way other than those described by other codes.
3.2.d	Processing: Repackaging	N/A	N/A	PK	Processing-repackaging	Preparation of a chemical substance for distribution in commerce in a different form, state, or quantity. This includes transferring the chemical substance from a bulk container into smaller containers. This definition does not apply to sites that only relabel or redistribute the reportable chemical substance without removing

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						the chemical substance from the container in which it is received or purchased.
3.2.e	Processing: As an impurity	N/A	N/A	N/A	N/A	N/A
3.2.f	Processing: Recycling	N/A	N/A	N/A	N/A	N/A
3.3.a	Otherwise Use: As a chemical processing aid	N/A	N/A	U	Use-non incorporative Activities	Chemical substance is otherwise used (*e.g.*, as a chemical processing or manufacturing aid).
3.3.a	Otherwise Use: As a chemical processing aid	Z101	Process Solvents	U029	Solvents (for cleaning or degreasing)	Chemical substances used to dissolve oils, greases, and similar materials from textiles, glassware, metal surfaces, and other articles. Examples include trichloroethylene, perchloroethylene, methylene chloride, liquid carbon dioxide, and n-propyl bromide.
3.3.a	Otherwise Use: As a chemical processing aid	Z102	Catalysts	U020	Photosensitive chemicals	Chemical substances used for their ability to alter their physical or chemical structure through absorption of light, resulting in the emission of light, dissociation, discoloration, or other chemical reactions. Examples include sensitizers, fluorescents, photovoltaic agents, ultraviolet absorbers, and ultraviolet stabilizers.
3.3.a	Otherwise Use: As a chemical processing aid	Z102	Catalysts	U025	Processing aids, specific to petroleum production	Chemical substances added to water-, oil-, or synthetic drilling muds or other petroleum production fluids to control viscosity, foaming, corrosion, alkalinity and pH, microbiological growth, hydrate formation, etc., during the production of oil, gas, and other products from beneath the earth's surface.
3.3.a	Otherwise Use: As a chemical processing aid	Z102	Catalysts	U026	Processing aids, not otherwise listed	Chemical substances used to improve the processing characteristics or the operation of process equipment or to alter or buffer the pH of the substance or mixture, when added to a process or to a substance or mixture to be

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						processed. Processing agents do not become a part of the reaction product and are not intended to affect the function of a substance or article created. Examples include buffers, dehumidifiers, dehydrating agents, sequestering agents, and chelators.
3.3.a	Otherwise Use: As a chemical processing aid	Z103	Inhibitors	U024	Process regulators	Chemical substances used to change the rate of a chemical reaction, start or stop the reaction, or otherwise influence the course of the reaction. Process regulators may be consumed or become part of the reaction product.
3.3.a	Otherwise Use: As a chemical processing aid	Z103	Inhibitors	U025	Processing aids, specific to petroleum production	Chemical substances added to water-, oil-, or synthetic drilling muds or other petroleum production fluids to control viscosity, foaming, corrosion, alkalinity and pH, microbiological growth, hydrate formation, etc., during the production of oil, gas, and other products from beneath the earth's surface.
3.3.a	Otherwise Use: As a chemical processing aid	Z103	Inhibitors	U026	Processing aids, not otherwise listed	Chemical substances used to improve the processing characteristics or the operation of process equipment or to alter or buffer the pH of the substance or mixture, when added to a process or to a substance or mixture to be processed. Processing agents do not become a part of the reaction product and are not intended to affect the function of a substance or article created. Examples include buffers, dehumidifiers, dehydrating agents, sequestering agents, and chelators.
3.3.a	Otherwise Use: As a chemical processing aid	Z104	Initiators	U024	Process regulators	Chemical substances used to change the rate of a chemical reaction, start, or stop the reaction, or otherwise influence the course of the reaction. Process regulators may be consumed or become part of the reaction product.
3.3.a	Otherwise Use: As a chemical	Z104	Initiators	U025	Processing aids, specific	Chemical substances added to water-, oil-, or synthetic drilling muds or other petroleum production fluids to

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
	processing aid				to petroleum production	control viscosity, foaming, corrosion, alkalinity and pH, microbiological growth, hydrate formation, etc., during the production of oil, gas, and other products from beneath the earth's surface.
3.3.a	Otherwise Use: As a chemical processing aid	Z104	Initiators	U026	Processing aids, not otherwise listed	Chemical substances used to improve the processing characteristics or the operation of process equipment or to alter or buffer the pH of the substance or mixture, when added to a process or to a substance or mixture to be processed. Processing agents do not become a part of the reaction product and are not intended to affect the function of a substance or article created. Examples include buffers, dehumidifiers, dehydrating agents, sequestering agents, and chelators.
3.3.a	Otherwise Use: As a chemical processing aid	Z105	Reaction Terminators	U024	Process regulators	Chemical substances used to change the rate of a chemical reaction, start, or stop the reaction, or otherwise influence the course of the reaction. Process regulators may be consumed or become part of the reaction product.
3.3.a	Otherwise Use: As a chemical processing aid	Z105	Reaction Terminators	U025	Processing aids, specific to petroleum production	Chemical substances added to water-, oil-, or synthetic drilling muds or other petroleum production fluids to control viscosity, foaming, corrosion, alkalinity and pH, microbiological growth, hydrate formation, etc., during the production of oil, gas, and other products from beneath the earth's surface.
3.3.a	Otherwise Use: As a chemical processing aid	Z105	Reaction Terminators	U026	Processing aids, not otherwise listed	Chemical substances used to improve the processing characteristics or the operation of process equipment or to alter or buffer the pH of the substance or mixture, when added to a process or to a substance or mixture to be processed. Processing agents do not become a part of the reaction product and are not intended to affect the function of a substance or article created. Examples include buffers,

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						dehumidifiers, dehydrating agents, sequestering agents, and chelators.
3.3.a	Otherwise Use: As a chemical processing aid	Z106	Solution Buffers	U026	Processing aids, not otherwise listed	Chemical substances used to improve the processing characteristics or the operation of process equipment or to alter or buffer the pH of the substance or mixture, when added to a process or to a substance or mixture to be processed. Processing agents do not become a part of the reaction product and are not intended to affect the function of a substance or article created. Examples include buffers, dehumidifiers, dehydrating agents, sequestering agents, and chelators.
3.3.a	Otherwise Use: As a chemical processing aid	Z199	Other	U002	Adhesives and sealant chemicals	Chemical substances used to promote bonding between other substances, promote adhesion of surfaces, or prevent seepage of moisture or air. Examples include epoxides, isocyanates, acrylamides, phenol, urea, melamine, and formaldehyde.
3.3.a	Otherwise Use: As a chemical processing aid	Z199	Other	U006	Bleaching agents	Chemical substances used to lighten or whiten a substrate through chemical reaction, usually an oxidative process which degrades the color system. Examples generally fall into one of two groups: chlorine containing bleaching agents (*e.g.*, chlorine, hypochlorite, N-chloro compounds and chlorine dioxide); and, peroxygen bleaching agents (*e.g.*, hydrogen peroxide, potassium permanganate, and sodium perborate).
3.3.a	Otherwise Use: As a chemical processing aid	Z199	Other	U018	Odor agents	Chemical substances used to control odors, remove odors, mask odors, or impart odors. Examples include benzenoids, terpenes and terpenoids, musk chemicals, aliphatic aldehydes, aliphatic cyanides, and mercaptans.
3.3.a	Otherwise Use: As a chemical processing aid	Z199	Other	U023	Plating agents and surface treating agents	Chemical substances applied to metal, plastic, or other surfaces to alter physical or chemical properties of the surface. Examples include metal surface treating agents, strippers,

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						etchants, rust and tarnish removers, and descaling agents.
3.3.a	Otherwise Use: As a chemical processing aid	Z199	Other	U025	Processing aids, specific to petroleum production	Chemical substances added to water-, oil-, or synthetic drilling muds or other petroleum production fluids to control viscosity, foaming, corrosion, alkalinity and pH, microbiological growth, hydrate formation, etc., during the production of oil, gas, and other products from beneath the earth's surface.
3.3.a	Otherwise Use: As a chemical processing aid	Z199	Other	U026	Processing aids, not otherwise listed	Chemical substances used to improve the processing characteristics or the operation of process equipment or to alter or buffer the pH of the substance or mixture, when added to a process or to a substance or mixture to be processed. Processing agents do not become a part of the reaction product and are not intended to affect the function of a substance or article created. Examples include buffers, dehumidifiers, dehydrating agents, sequestering agents, and chelators.
3.3.a	Otherwise Use: As a chemical processing aid	Z199	Other	U028	Solid separation agents	Chemical substances used to promote the separation of suspended solids from a liquid. Examples include flotation aids, flocculants, coagulants, dewatering aids, and drainage aids.
3.3.b	Otherwise Use: As a manufacturing aid	N/A	N/A	U	Use−non incorporative Activities	Chemical substance is otherwise used (*e.g.*, as a chemical processing or manufacturing aid).
3.3.b	Otherwise Use: As a manufacturing aid	Z201	Process Lubricants	U017	Lubricants and lubricant additives	Chemical substances used to reduce friction, heat, or wear between moving parts or adjacent solid surfaces, or that enhance the lubricity of other substances. Examples of lubricants include mineral oils, silicate and phosphate esters, silicone oil, greases, and solid film lubricants such as graphite and PTFE. Examples of lubricant additives include molybdenum disulphide and tungsten disulphide.

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
3.3.b	Otherwise Use: As a manufacturing aid	Z202	Metalworking Fluids	U007	Corrosion inhibitors and antiscaling agents	Chemical substances used to prevent or retard corrosion or the formation of scale. Examples include phenylenediamine, chromates, nitrates, phosphates, and hydrazine.
3.3.b	Otherwise Use: As a manufacturing aid	Z202	Metalworking Fluids	U014	Functional fluids (open systems)	Liquid or gaseous chemical substances used for one or more operational properties in an open system. Examples include antifreezes and de−icing fluids such as ethylene and propylene glycol, sodium formate, potassium acetate, and sodium acetate. This code also includes substances incorporated into metal working fluids.
3.3.b	Otherwise Use: As a manufacturing aid	Z203	Coolants	U013	Functional fluids (closed systems)	Liquid or gaseous chemical substances used for one or more operational properties in a closed system. Examples include heat transfer agents (*e.g.*, coolants and refrigerants) such as polyalkylene glycols, silicone oils, liquified propane, and carbon dioxide; hydraulic/transmission fluids such as mineral oils, organophosphate esters, silicone, and propylene glycol; and dielectric fluids such as mineral insulating oil and high flash point kerosene. This code does not include fluids used as lubricants.
3.3.b	Otherwise Use: As a manufacturing aid	Z204	Refrigerants	U013	Functional fluids (closed systems)	Liquid or gaseous chemical substances used for one or more operational properties in a closed system. Examples include heat transfer agents (*e.g.*, coolants and refrigerants) such as polyalkylene glycols, silicone oils, liquified propane, and carbon dioxide; hydraulic/transmission fluids such as mineral oils, organophosphate esters, silicone, and propylene glycol; and dielectric fluids such as mineral insulating oil and high flash point kerosene. This code does not include fluids used as lubricants.

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
3.3.b	Otherwise Use: As a manufacturing aid	Z205	Hydraulic Fluids	U013	Functional fluids (closed systems)	Liquid or gaseous chemical substances used for one or more operational properties in a closed system. Examples include heat transfer agents (*e.g.*, coolants and refrigerants) such as polyalkylene glycols, silicone oils, liquified propane, and carbon dioxide; hydraulic/transmission fluids such as mineral oils, organophosphate esters, silicone, and propylene glycol; and dielectric fluids such as mineral insulating oil and high flash point kerosene. This code does not include fluids used as lubricants.
3.3.b	Otherwise Use: As a manufacturing aid	Z299	Other	U013	Functional fluids (closed systems)	Liquid or gaseous chemical substances used for one or more operational properties in a closed system. Examples include heat transfer agents (*e.g.*, coolants and refrigerants) such as polyalkylene glycols, silicone oils, liquified propane, and carbon dioxide; hydraulic/transmission fluids such as mineral oils, organophosphate esters, silicone, and propylene glycol; and dielectric fluids such as mineral insulating oil and high flash point kerosene. This code does not include fluids used as lubricants.
3.3.b	Otherwise Use: As a manufacturing aid	Z299	Other	U023	Plating agents and surface treating agents	Chemical substances applied to metal, plastic, or other surfaces to alter physical or chemical properties of the surface. Examples include metal surface treating agents, strippers, etchants, rust and tarnish removers, and descaling agents.
3.3.c	Otherwise Use: Ancillary or other use	N/A	N/A	U	Use−non incorporative Activities	Chemical substance is otherwise used (*e.g.*, as a chemical processing or manufacturing aid).
3.3.c	Otherwise Use: Ancillary or other use	Z301	Cleaner	U007	Corrosion inhibitors and antiscaling agents	Chemical substances used to prevent or retard corrosion or the formation of scale. Examples include phenylenediamine, chromates, nitrates, phosphates, and hydrazine.

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
3.3.c	Otherwise Use: Ancillary or other use	Z301	Cleaner	U029	Solvents (for cleaning or degreasing)	Chemical substances used to dissolve oils, greases, and similar materials from textiles, glassware, metal surfaces, and other articles. Examples include trichloroethylene, perchloroethylene, methylene chloride, liquid carbon dioxide, and n-propyl bromide.
3.3.c	Otherwise Use: Ancillary or other use	Z302	Degreaser	U003	Adsorbents and Absorbents	Chemical substances used to retain other substances by accumulation on their surface or by assimilation. Examples of adsorbents include silica gel, activated alumina, and activated carbon. Examples of absorbents include straw oil, alkaline solutions, and kerosene.
3.3.c	Otherwise Use: Ancillary or other use	Z302	Degreaser	U029	Solvents (for cleaning or degreasing)	Chemical substances used to dissolve oils, greases, and similar materials from textiles, glassware, metal surfaces, and other articles. Examples include trichloroethylene, perchloroethylene, methylene chloride, liquid carbon dioxide, and n-propyl bromide.
3.3.c	Otherwise Use: Ancillary or other use	Z303	Lubricant	U017	Lubricants and lubricant additives	Chemical substances used to reduce friction, heat, or wear between moving parts or adjacent solid surfaces, or that enhance the lubricity of other substances. Examples of lubricants include mineral oils, silicate and phosphate esters, silicone oil, greases, and solid film lubricants such as graphite and PTFE. Examples of lubricant additives include molybdenum disulphide and tungsten disulphide.
3.3.c	Otherwise Use: Ancillary or other use	Z304	Fuel	U012	Fuels and fuel additives	Chemical substances used to create mechanical or thermal energy through chemical reactions, or which are added to a fuel for the purpose of controlling the rate of reaction or limiting the production of undesirable combustion products, or which provide other benefits such as corrosion inhibition, lubrication, or detergency. Examples of fuels include coal, oil, gasoline, and various grades

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						of diesel fuel. Examples of fuel additives include oxygenated compound such as ethers and alcohols, antioxidants such as phenylenediamines and hindered phenols, corrosion inhibitors such as carboxylic acids, amines, and amine salts, and blending agents such as ethanol.
3.3.c	Otherwise Use: Ancillary or other use	Z305	Flame Retardant	U011	Flame retardants	Chemical substances used on the surface of or incorporated into combustible materials to reduce or eliminate their tendency to ignite when exposed to heat or a flame for a short period of time. Examples include inorganic salts, chlorinated, or brominated organic compounds, and organic phosphates/phosphonates.
3.3.c	Otherwise Use: Ancillary or other use	Z306	Waste Treatment	U006	Bleaching agents	Chemical substances used to lighten or whiten a substrate through chemical reaction, usually an oxidative process which degrades the color system. Examples generally fall into one of two groups: chlorine containing bleaching agents (*e.g.*, chlorine, hypochlorites, N-chloro compounds and chlorine dioxide); and peroxygen bleaching agents (*e.g.*, hydrogen peroxide, potassium permanganate, and sodium perborate).
3.3.c	Otherwise Use: Ancillary or other use	Z306	Waste Treatment	U018	Odor agents	Chemical substances used to control odors, remove odors, mask odors, or impart odors. Examples include benzenoids, terpenes and terpenoids, musk chemicals, aliphatic aldehydes, aliphatic cyanides, and mercaptans.
3.3.c	Otherwise Use: Ancillary or other use	Z306	Waste Treatment	U019	Oxidizing/reducing agent	Chemical substances used to alter the valence state of another substance by donating or accepting electrons or by the addition or removal of hydrogen to a substance. Examples of oxidizing agents include nitric acid, perchlorates, hexavalent chromium compounds, and peroxydisulfuric acid salts. Examples of reducing agents include hydrazine, sodium thiosulfate, and coke produced from coal.

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
3.3.c	Otherwise Use: Ancillary or other use	Z306	Waste Treatment	U028	Solid separation agents	Chemical substances used to promote the separation of suspended solids from a liquid. Examples include flotation aids, flocculants, coagulants, dewatering aids, and drainage aids.
3.3.c	Otherwise Use: Ancillary or other use	Z307	Water Treatment	U006	Bleaching agents	Chemical substances used to lighten or whiten a substrate through chemical reaction, usually an oxidative process which degrades the color system. Examples generally fall into one of two groups: chlorine containing bleaching agents (*e.g.*, chlorine, hypochlorites, N-chloro compounds and chlorine dioxide); and peroxygen bleaching agents (*e.g.*, hydrogen peroxide, potassium permanganate, and sodium perborate).
3.3.c	Otherwise Use: Ancillary or other use	Z307	Water Treatment	U018	Odor agents	Chemical substances used to control odors, remove odors, mask odors, or impart odors. Examples include benzenoids, terpenes and terpenoids, musk chemicals, aliphatic aldehydes, aliphatic cyanides, and mercaptans.
3.3.c	Otherwise Use: Ancillary or other use	Z307	Water Treatment	U019	Oxidizing/reducing agent	Chemical substances used to alter the valence state of another substance by donating or accepting electrons or by the addition or removal of hydrogen to a substance. Examples of oxidizing agents include nitric acid, perchlorates, hexavalent chromium compounds, and peroxydisulfuric acid salts. Examples of reducing agents include hydrazine, sodium thiosulfate, and coke produced from coal.
3.3.c	Otherwise Use: Ancillary or other use	Z307	Water Treatment	U028	Solid separation agents	Chemical substances used to promote the separation of suspended solids from a liquid. Examples include flotation aids, flocculants, coagulants, dewatering aids, and drainage aids.
3.3.c	Otherwise Use: Ancillary or other use	Z308	Construction Materials	N/A	N/A	N/A
3.3.c	Otherwise Use:	Z399	Other	U001	Abrasives	Chemical substances used to wear down or polish surfaces by rubbing against the surface. Examples include

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
	Ancillary or other use					sandstones, pumice, silex, quartz, silicates, aluminum oxides, and glass.
3.3.c	Otherwise Use: Ancillary or other use	Z399	Other	U013	Functional fluids (closed systems)	Liquid or gaseous chemical substances used for one or more operational properties in a closed system. Examples include heat transfer agents (*e.g.*, coolants and refrigerants) such as polyalkylene glycols, silicone oils, liquified propane, and carbon dioxide; hydraulic/transmission fluids such as mineral oils, organophosphate esters, silicone, and propylene glycol; and dielectric fluids such as mineral insulating oil and high flash point kerosene. This code does not include fluids used as lubricants.
3.3.c	Otherwise Use: Ancillary or other use	Z399	Other	U014	Functional fluids (open systems)	Liquid or gaseous chemical substances used for one or more operational properties in an open system. Examples include antifreezes and de-icing fluids such as ethylene and propylene glycol, sodium formate, potassium acetate, and sodium acetate. This code also includes substances incorporated into metal working fluids.
3.3.c	Otherwise Use: Ancillary or other use	Z399	Other	U018	Odor agents	Chemical substances used to control odors, remove odors, mask odors, or impart odors. Examples include benzenoids, terpenes and terpenoids, musk chemicals, aliphatic aldehydes, aliphatic cyanides, and mercaptans.
3.3.c	Otherwise Use: Ancillary or other use	Z399	Other	U020	Photosensitive chemicals	Chemical substances used for their ability to alter their physical or chemical structure through absorption of light, resulting in the emission of light, dissociation, discoloration, or other chemical reactions. Examples include sensitizers, fluorescents, photovoltaic agents, ultraviolet absorbers, and ultraviolet stabilizers.
3.3.c	Otherwise Use: Ancillary or other use	Z399	Other	U023	Plating agents and surface treating agents	Chemical substances applied to metal, plastic, or other surfaces to alter physical or chemical properties of the surface. Examples include metal

TRI Section	TRI Description	TRI Sub-use Code	TRI Sub-use Code Name	2016 CDR Code	2016 CDR Code Name	2016 CDR Functional Use Definition
						surface treating agents, strippers, etchants, rust and tarnish removers, and descaling agents.

5531

Appendix G GUIDANCE FOR USING THE NATIONAL EMISSIONS INVENTORY AND TOXIC RELEASE INVENTORY FOR ESTIMATING AIR RELEASES

This appendix provides guidance for using EPA's NEI and TRI data to estimate air releases for certain chemicals undergoing risk evaluation under TSCA. These estimates will be used as inputs to air modeling for the purposes of estimating ambient air concentrations.

G.1 Background

EPA's NEI and TRI programs require individual facilities, as well as state, local, and tribal (SLT) Air Agencies, to report information on airborne chemical releases to the EPA. While the chemicals reported under each program differ, both inventories include data for some of the chemicals undergoing TSCA risk evaluation. When available, the NEI and TRI data include information on the sources, magnitude, and nature (*e.g.*, stack vs. fugitive, stack height, stack gas velocity/temperature) of airborne releases from industrial/commercial facilities and other smaller emissions sources. Thus, these databases may provide useful information for estimating air releases of TRI- and/or NEI-covered chemicals, for certain OESs.

As the NEI and TRI programs operate under separate regulatory frameworks, the data reported under these programs do not always overlap. For example, in 2017, approximately 745,000 lb of perchloroethylene (PERC) air emissions were reported to TRI, whereas approximately 16.6 million lb of PERC air emissions were reported to NEI. This document provides an approach for using NEI data, in combination with TRI data, to estimate air emissions.

G.2 Obtaining Air Emissions Data

G.2.1 Obtaining NEI Data

NEI emissions data is categorized into (1) point source data, (2) area or nonpoint source data, (3) onroad mobile source data, and (4) nonroad mobile source data. EPA included only point source data categories in the assessment of environmental releases in this risk evaluation. Point sources are stationary sources of air emissions from facilities with operating permits under Title V of the CAA, also called "major sources." Major sources are defined as having actual or potential emissions at or above the major source thresholds. Although thresholds can vary for certain chemicals in NAAQS non-attainment areas, the default threshold is 100 tons/year for non-HAPs, 10 tons per year for a single HAP, or 25 tons per year for any combination of HAPs. Point source facilities include large energy and industrial sites and are reported at the emission unit- and release point-level.

Area or nonpoint sources are stationary sources that do not qualify as major sources. The nonpoint data are aggregated and reported at the county-level and include emissions from smaller facilities as well as agricultural emissions, construction dust, and open burning. Industrial and commercial/institutional fuel combustion, gasoline distribution, oil and gas production and extraction, publicly owned treatment works, and solvent emissions may be reported in the point or nonpoint source categories depending upon source size. EPA targeted its review of environmental releases to point sources, and did not review the road, nonroad, and other automotive exhaust information identified.

Onroad mobile sources include emissions from onroad vehicles that combust liquid fuels during operation, including passenger cars, motorcycles, trucks, and buses. The nonroad mobiles sources data include emissions from other mobile sources that are not typically operated on public roadways, such as

locomotives, aircraft, commercial marine vessels, recreational equipment, and landscaping equipment. Onroad and nonroad mobile data is reported in the same format as nonpoint data; however, it is not available for every chemical. EPA did not include area or nonpoint sources in the assessment of environmental releases in this risk evaluation. Further details on EPA's approach to using NEI data for estimating releases are described in Section 2.3.3.2, Appendix F, and F.1.

The first step in using NEI data to estimate air releases is to obtain the NEI data in a workable format that provides the requisite data for release estimation and modeling. The NEI data are available on EPA's NEI public website as downloadable zip files, divided into onroad, nonroad, nonpoint, and point source data files. The zipped point source data files are extremely large and require specialized database experience to query and manipulate. As an alternative, EPA's EIS Gateway allows registered EPA users, registered SLT users, and approved contractors to query and download NEI data and associated reporting code descriptions. As a result, this methodology uses the EIS Gateway to query point source data. Following download, the point and nonpoint emissions data for the chemical of interest will be imported into an MS Excel spreadsheet (or using an alternative tool, if the data exceeds Excel's size threshold), to be filtered and manipulated. At this point, EPA will use the EIS lookup tables to populate field descriptions for data fields reported as numerical codes (*e.g.*, NAICS code).

G.2.2 Obtaining TRI Data

TRI data may be downloaded from EPA's public TRI Program and TRI Data and Tools website. Once the csv file(s) has (have) been downloaded, the data are filtered by the chemical of interest using the CAS number and/or chemical name. Relevant NEI data fields include reporting year, facility identifying information (*e.g.*, name, address, FRS ID, and TRIFID), chemical information (chemical name, CASRN), primary NAICS codes, fugitive air releases, and stack air releases.

G.3 Mapping NEI and TRI DATA to Occupational Exposure Scenarios

Once TRI and NEI data is obtained, the next step is to map the data to OESs. For procedures for mapping facilities from TRI and NEI to OESs, refer to Appendix F.

G.4 Estimating Air Releases Using NEI and TRI Data

EPA will use the mapped NEI and TRI data to develop facility- and/or release-point-specific emissions estimates for chemicals undergoing TSCA risk evaluation. The data summary will include pertinent information for risk evaluation and emission modeling, such as facility location, annual releases, daily releases, operating information, release type (*i.e.*, stack vs. fugitive), and stack parameters.

G.4.1 Linking NEI and TRI Data

Although NEI and TRI have different reporting requirements, some major sources are expected to report to both databases. The most reliable way to link the datasets is with a common identifier. NEI reports EIS Facility Identifier and Facility Registry Identifier (FRSID), although the latter is not reliably populated for all NEI records. TRI reports TRI Facility ID and FRSID. EPA will use its database of EIS Alternate Facility Identifiers ("EISAltFacilityIdentifiers_20211221.accdb") to link TRIFID to an EIS Facility Identifier. Linkages may be confirmed and/or refined using facility names and addresses, if necessary.

Following linkage, EPA will review the linked NEI/TRI data to ensure that facilities with records in both databases are assigned to a consistent OES. When discrepancies arise, the Agency will resolve these discrepancies using the dataset with the greatest level of detail. In general, NEI provides more detailed air emissions data than TRI. For example, NEI reports SCC levels 1 to 4, which provide insight

into the specific operations and/or process units associated with NEI-reported air emissions. For example, "Chemical Evaporation Organic Solvent Evaporation Degreasing Entire Unit: Open-top Vapor Degreasing" is a SCC description used in the NEI. This SCC description identifies the emission unit, not only as a degreaser, but as a specific type of degreaser. NEI also includes free text fields where reporters can include additional information about a particular facility and/or emission unit. TRI does not provide this level of detail.

Following a review of OES assignments, the TRI and NEI data will be divided into separate tables by OES code, which may be linked using the EIS Facility Identifier.

G.4.2 Evaluation of Sub-annual Emissions

As air emissions data in TRI and NEI are reported as annual values, sub-annual (*e.g.,* daily) emissions must be calculated from information on release duration, release days, and release pattern. While TRI does not report information on release duration or pattern, this information may be estimated from operating data reported to the NEI.[17] Other sources of release duration and pattern information include GSs and ESDs, literature sources, process information, and standard engineering methodology for estimating number of release days. These sources are described in further detail below, in order of preference.

Sources for Estimating Release Duration

1. *NEI Data* – The NEI dataset includes facility-specific air emissions estimates for major sources and often includes data on the number of hours of operation per day for these facilities. The number of operating hours from NEI can be used to inform release duration for the specific facilities being assessed. Hours of operation for one facility in NEI are typically not used for a different facility; however, engineers may consider conducting an analysis of operating hours for multiple facilities in NEI that are a part of the same OES to develop a broader estimate of release duration at the OES-level. EPA has previously used this approach to inform development of GS/ESDs, but it is dependent on the amount of data and time available and should be discussed on a chemical-specific basis.

2. *Models* – Models used to estimate air emissions and associated inhalation exposures (*e.g.,* Tank Truck and Railcar Loading and Unloading Release and Inhalation Exposure Model, Open-Top Vapor Degreasing Near-Field/Far-Field Inhalation Exposure Model, Spot Cleaning Near-Field/Far-Field Inhalation Exposure Model, models from GS/ESDs) sometimes include data on release duration, which are usually either cited from literature or based on generic assumptions about the activity being modeled. Release duration information from models may be presented with non-modeled air emission data from NEI or TRI, if the model is applicable and expected to represent the primary release source for the OES (*e.g.,* release duration from the Tank Truck and Railcar Loading and Unloading Release and Inhalation Exposure Model may be used with estimates of air emissions for a facility in the Repackaging OES). For models that calculate release duration as a distribution, such as from Monte Carlo simulations, the mean and range of release durations from the model should be presented with the air emission estimate.

3. *Literature* – Literature sources from systematic review, including GS/ESDs, are another source of information for release duration. Often, release duration information from literature sources may be broad, such as a range of durations for a given operation. Alternatively, literature sources may describe release duration qualitatively, such as "on and off throughout the day" or "over half the day". Therefore, literature sources may inform release duration at the OES-level, as opposed

[17] Note that the NEI operating hours fields are not populated for all, or in the case of ethylene dibromide, most, NEI entries.

to at the facility-level. All details from literature sources on release duration, including qualitative descriptions, should be presented with air emission estimates if they are available and there is no other source of this data.

4. *List as "Unknown"* – Often, no information on release duration is available at either the facility or OES-level from the above sources. In these cases, engineers should list that the release duration is unknown.

Sources for Estimating Release Pattern

1. *NEI Data* – The NEI dataset includes facility-specific air emissions estimates for major sources and often includes data on the number of days of operation per week and number of weeks of operation per year for these facilities. NEI does not indicate if the number of days per week or weeks per year of operation are consecutive or intermittent throughout the week/year; however, these data are still useful and should be provided by engineers with air emission estimates to help inform release patterns. Data on operational days per week and weeks per year for one facility in NEI is typically not used for a different facility; however, engineers may consider conducting an analysis of these data for multiple facilities in NEI that are a part of the same OES to develop a broader estimate of release pattern at the OES-level. EPA has previously used this approach to inform development of GS/ESDs, but it is dependent on the amount of data and time available and should be discussed on a chemical-specific basis.

2. *Models* – Models used to estimate air emissions (*e.g.*, Tank Truck and Railcar Loading and Unloading Release and Inhalation Exposure Model, Open-Top Vapor Degreasing Near-Field/Far-Field Inhalation Exposure Model, Spot Cleaning Near-Field/Far-Field Inhalation Exposure Model, models from GS/ESDs) sometimes, but rarely, include data on release pattern from the underlying data sources. Release pattern information from models may be presented with non-modeled air emission data (*e.g.*, NEI, TRI) if the model is applicable and expected to represent the primary release source for the OES (*e.g.*, release pattern from the Tank Truck and Railcar Loading and Unloading Release and Inhalation Exposure Model may be used with estimates of air emissions for a facility in the Repackaging OES).

3. *Literature* – Literature sources from systematic review, including GS/ESDs, are another source of information for release pattern. Often, literature sources provide general release pattern information for a given operation. Therefore, literature sources may inform release pattern at the OES-level, as opposed to at the facility-level. All details from literature sources on release pattern, even if general and/or limited, should be presented with air emission estimates, if they are available and there is no other source of this information.

4. *List as "Unknown" and Provide Operating Days* – Often, no information on release pattern is available at either the facility or OES-level from the above sources. In these cases, engineers should do the following:
    a. List that the release pattern is unknown.
    b. Provide the number of operating days for the facility based on project-level engineering methodology, which is summarized below.
    c. Provide any information based on process knowledge (*e.g.*, commercial aerosol degreasing using cans may occur on/off throughout a day and year).

Estimating Number of Operating Days for Point Sources

For major sources that report operating data to NEI, EPA will use these data to calculate operating hours on a days per year basis. For major sources that do not report operating data in NEI (including facilities that only report to TRI), EPA will estimate operating hours using the other data sources described above. A hierarchical approach for estimating the number of facility operating days per year is described below.

1. *Facility-Specific Data* – Use facility-specific data, if available. NEI reports operating data as hours per year, hours per day, days per week, and weeks per year.
    a. If possible, calculate operating days per years as: Days/yr = hours per year ÷ hours per day.
    b. If hours per year and/or hours per day are not reported, calculate days per year as: Days/yr = Days per week × weeks per year.
2. *Facility-Specific Use Rates* – If information on facility-specific use rates is available, estimate days/yr using one of the following approaches:
    a. If facilities have known or estimated average daily use rates, calculate the days/yr as: Days/yr = Estimated Annual Use Rate for the Site (kg/yr) ÷ average daily use rate from sites with available data (kg/day).
    b. If sites without days/yr data do not have known or estimated average daily use rates, use the average number of days/yr from the sites with such data.
3. *Industry-Specific Data* – Industry-specific data may be available in the form of GSs, ESDs, trade publications, or other relevant literature. In such cases, these estimates should take precedent over other approaches, unless facility-specific data are available.
4. *Manufacture of Large-PV Commodity Chemicals* – For the manufacture of the large-PV commodity chemicals, a value of 350 days/yr should be used. This assumes the plant runs 7 day/week and 50 week/yr (with 2 weeks down for turnaround) and assumes that the plant is always producing the chemical.
5. *Manufacture of Lower-PV Specialty Chemicals* – For the manufacture of lower-PV specialty chemicals, it is unlikely the chemical is being manufactured continuously throughout the year. Therefore, a value of 250 days/yr should be used. This assumes the plant manufactures the chemical 5 days/week and 50 weeks/yr (with 2 weeks down for turnaround).
6. *Processing as Reactant (Intermediate Use) in the Manufacture of Commodity Chemicals* – As noted above, the manufacture of commodity chemicals is assumed to occur 350 days/yr such that the use of a chemical as a reactant to manufacture a commodity chemical will also occur 350 days/yr.
7. *Processing as Reactant (Intermediate Use) in the Manufacture of Specialty Chemicals* – As noted above, the manufacture of specialty chemicals is not likely to occur continuously throughout the year. Therefore, a value of 250 days/yr can be used.
8. *Other Chemical Plant OES (e.g., Processing into formulation and Use of industrial processing aids)* – For these OESs, it is reasonable to assume that the chemical of interest is not always in use at the facility, even if the facility operates 24/7. Therefore, a value of 300 days/yr can be used, based on the European Solvent Industry Group's "SpERC fact sheet – Formulation & (re)packing of substances and mixtures – Industrial (Solvent-borne)" default of 300 days/yr for the chemical industry. However, in instances where the OES uses a low volume of the chemical of interest, 250 days/yr can be used as a lower estimate for the days/yr.
9. *All Other OESs* – Regardless of facility operating schedule, other OESs are unlikely to use the chemical of interest every day. Therefore, a value of 250 days/yr should be used for these OESs.

Estimating Number of Operating Days for Area Sources

For area sources, EPA will also estimate operating days per year using information such as NEI operating data for major source facilities within the same OES, general information about the OES, and values from literature.

Facility operating days per year will be used to calculate daily emissions from the NEI and TRI annual emissions data, as follows:

Daily emissions (kg/day) = Annual emissions (kg/yr) ÷ Operating days per year (days/yr)