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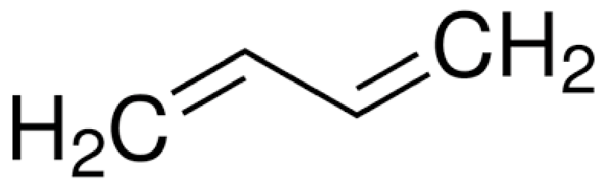
United States
Environmental Protection Agency

Risk Evaluation for 1,3-Butadiene

CASRN 106-99-0



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Docket

Supporting information can be found in the following public dockets, Docket IDs: EPA-HQ-OPPT-2018-0451 and EPA-HQ-OPPT-2024-0425.

Disclaimer

Authors: Kiet Ly and Aderonke Adegbule (Assessment Leads), Sheila Healy (Branch Supervisor), Melody Bernot, Nicholas Blelloch, Marcy Card, Scott Drewes, Marc Edmonds, Victoria Ellenbogen, Kathleen Ferry, Ann Huang, Keith Jacobs, Ed Lo, Abhilash Sasidharan, Kyle Spatz, Kelley Stanfield, Michael Stracka, Catherine Taylor, and Kevin Vuilleumier

Contributors: Thomas Bateson, Juan Bezares-Cruz, Maggie Clark, Peter Egeghy, Bridget Eklund, Sara Fritz-Davidson, Grant Goedjen, Bryan Groza, Kristin Isaacs, Leonid Kopylev, Danielle Johnson, David Lynch, Gerardo Ruiz-Mercado, James Sanders, Kelsey Vitense, and John Wambaugh

Technical Support: Mark Gibson, Hillary Hollinger, Grace Kaupas, Yadi Lopez, Azah Abdalla Mohamed, Sydney Nguyen, Lauren O’Connor, Joseph Rappold, and Cory Strope

External Peer Review Support: Alie Muneer and Gene Stroup (Branch Supervisor)

EXECUTIVE SUMMARY

Background

EPA evaluated the health and environmental risks of the chemical 1,3-butadiene across its conditions of use (COUs) under the Toxic Substances Control Act (TSCA), ranging from manufacture to disposal. Of 30 COUs evaluated, the Agency determined that 1,3-butadiene presents an unreasonable risk of injury to human health for workers for non-cancer and cancer risk driven by inhalation exposure from 11 COUs, and for occupational non-users (ONUs) from 1 COU. The Agency did not identify unreasonable risk to consumers associated with any COU as a significant contributor to the unreasonable risk determination for 1,3-butadiene. EPA determined that general population pathways, including those for fenceline communities, do not significantly contribute to unreasonable risk from 1,3-butadiene. EPA also determined that environmental exposures via soil, air, surface water, and sediment under the COUs do not significantly contribute to unreasonable risk to the environment from 1,3-butadiene.

In December 2019, EPA designated 1,3-butadiene as a high priority substance for risk evaluation and in 2020 followed with the public release of the *Final Scope of the Risk Evaluation for 1,3-Butadiene; CASRN 106-99-0* ("final scope") (U.S. EPA, 2020c). This risk evaluation assesses human health risk to workers, ONUs; consumers, including bystanders; and the general population exposed to 1,3-butadiene. It also assesses risk to the environment, including risk to aquatic and terrestrial species. In alignment with the final scope, EPA evaluated all reasonably available physical and chemical properties, environmental fate, and environmental release data and determined that air is the major exposure pathway.

1,3-Butadiene is a colorless gas with domestic manufacturers reporting through 2019 TSCA Chemical Data Reporting (CDR) production volumes (PVs) ranging from 1 to 5 billion pounds under Chemical Abstracts Service Registry Number (CASRN) 106-99-0. EPA describes PVs as a range to protect confidential business information (CBI). Produced during petrochemical processing, 1,3-butadiene aids petrochemical manufacturing and is primarily used to produce plastic and synthetic rubber products such as tires. 1,3-Butadiene polymers are also used as in adhesives, lubricants, and paints and coatings.

The Agency designated 1,3-butadiene as a high priority chemical for risk evaluation because both laboratory animal and human data show that it may be harmful to people if they are exposed to a sufficient concentration of the chemical substance over a prolonged period of time. 1,3-Butadiene is associated with health effects including reproductive and developmental toxicity, blood disease, and cancer. Robust human occupational cohort studies link workers' exposure to 1,3-butadiene with increases in lymphatic and hematopoietic cancers as well as bladder cancer, which is consistent with lymphomas observed in exposed laboratory mice. The human health hazard of 1,3-butadiene has been assessed by multiple national and international governmental organizations and is broadly regulated by EPA, various states, and other countries (see Appendix B). EPA considered the databases reviewed in these prior assessments but made independent conclusions based on the systematic review approach (U.S. EPA, 2021a) and the best available science.

Determining Unreasonable Risk to Human Health

EPA's TSCA existing chemical risk evaluations must determine whether a chemical substance does or does not present unreasonable risk to human health or the environment under its COUs. The unreasonable risk must be informed by the best available science. The Agency, in making the finding of presents unreasonable risk to human health and the environment, considered risk-related factors as described in its 2024 risk evaluation framework rule at 15 U.S.C. § 2605(b)(4)(F). Risk-related factors that EPA identified include but are not limited to the type of health effect under consideration; the reversibility of the health effect being evaluated; exposure-related considerations (*e.g.*, duration, magnitude, frequency of exposure); population exposed (including any potentially exposed or susceptible subpopulations [PESS]); and EPA's confidence in the information used to inform the hazard and exposure values. These considerations are included as part of an evaluation of hazard and exposure to 1,3-butadiene. If an estimate of risk for a specific scenario exceeds the standard risk benchmarks (see Section 5.3.1), then the determination of whether those risks significantly contribute to the unreasonable risk of 1,3-butadiene under COUs is both case-by-case and context-driven. EPA considers all of the aforementioned risk-related factors when making a determination of whether a COU significantly contributes to unreasonable risk for a chemical substance.

EPA evaluated the risks to people from exposure to 1,3-butadiene at work and outdoors. Given the environmental fate properties of 1,3-butadiene, an in-depth analysis of releases to water or land and associated environmental exposures was *not* conducted. When it is manufactured or used to make products, 1,3-butadiene is mainly released into the air due to its volatility, with relatively small releases to land or water. If released to water or land, 1,3-butadiene will quickly volatilize from water and land surfaces. 1,3-Butadiene breaks down in the air within a few hours by reacting with hydroxyl (·OH) or nitrate (NO_3·) radicals in the atmosphere. The degradation pathway is detailed in the *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae), including the rationale for excluding degradates in this risk evaluation. Additional sources of 1,3-butadiene exposure come from vehicle exhaust, tobacco smoke, burning wood, and forest fires. Consistent with 1,3-butadiene's physical and chemical properties, the Agency for Toxic Substances and Disease Registry (ATSDR (2012)) concluded that inhalation is the predominant route for human exposures and 1,3-butadiene has not been quantified by any other routes.

Workers may be exposed to 1,3-butadiene when using 1,3-butadiene in the workplace. The general population—specifically, people who reside near facilities that manufacture or process 1,3-butadiene—may be exposed when those facilities release 1,3-butadiene into the air. In determining whether 1,3-butadiene presents an unreasonable risk of injury to human health, EPA incorporated the following PESS into its assessment: females of reproductive age, males of reproductive age, pregnant females, infants, children and adolescents, people exposed to 1,3-butadiene in the workplace, and populations who reside near 1,3-butadiene-releasing facilities. These subpopulations are PESS because some have greater exposure to 1,3-butadiene or exhibit greater biological susceptibility than the general population.

In this risk evaluation, EPA quantitatively evaluated risks resulting from exposure to 1,3-butadiene from facilities that use, manufacture, or process 1,3-butadiene under industrial and/or commercial COUs subject to TSCA and the products that result from such manufacture and processing. Human or environmental exposure to 1,3-butadiene from other sources (*e.g.*, vehicle exhaust, tobacco smoke, woodburning) were *not* quantitatively evaluated for risk characterization by EPA in reaching its determination of unreasonable risk to injury of human health but were qualitatively considered through discussion of AirToxScreen in Section 2.3.3.2 of the *General Population Exposure for 1,3-Butadiene* (U.S. EPA, 2025u).

Based on the occupational risk estimates and related risk factors, EPA has determined that 11 COUs significantly contribute to the unreasonable risk of 1,3-butadiene to workers, including 1 COU that also significantly contributes to unreasonable risk to ONUs due to non-cancer and cancer risk driven by inhalation exposure.

Based on the assessment of consumer risk estimates and related risk factors, EPA has determined that no consumer COUs significantly contribute to unreasonable risk of 1,3-butadiene. Based on the assessment of general population risk estimates and related risk factors, the Agency has determined that inhalation non-cancer and cancer risks from 1,3-butadiene do not significantly contribute to unreasonable risk to the general population, including fenceline communities. Furthermore, exposures to 1,3-butadiene from the land, surface water, sediment, and drinking water pathways also do not significantly contribute to unreasonable risk of 1,3-butadiene to human health.

Determining Unreasonable Risk to the Environment

In determining whether 1,3-butadiene presents an unreasonable risk of injury to the environment, EPA considered the following groups of organisms in its assessment: aquatic vertebrates, aquatic invertebrates, benthic invertebrates, algae, terrestrial mammals, and soil invertebrates. The Agency weighed the scientific evidence to determine confidence levels in underlying datasets and risk estimates for the environment.

Based on the risk evaluation for 1,3-butadiene—including the populations and exposures assessed, the environmental effects, consideration of uncertainties, as well as the physical-chemical properties of 1,3-butadiene (*e.g.*, high volatility and reactivity, low sorption to organic material, low water solubility) and low potential for exposure—EPA did *not* identify significant contributions to unreasonable risk to the environment for 1,3-butadiene under any COU.

Conclusions

EPA evaluated a total of 30 COUs for 1,3-butadiene detailed in Section 2.2 with subsequent exposures and risk characterizations for human health and to environmental species in Sections 5 and 6, respectively.

The Agency determined that of 30 COUs evaluated, the following 11 COUs significantly contribute to the unreasonable risk of injury to human health due to non-cancer risks from intermediate inhalation exposure to workers:

- Manufacturing – domestic manufacturing;
- Manufacturing – importing;
- Processing as a reactant – intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing);
- Processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – plasticizer (asphalt paving, roofing, and coating materials manufacturing);
- Processing – incorporation into article – monomer (rubber product manufacturing);
- Processing – use-non-incorporative activities – fuel (petroleum refineries);
- Processing – repackaging – (wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing);
- Processing – recycling; and
- Disposal.

EPA determined that the following COUs also significantly contribute to unreasonable risk of injury to human health due to cancer risks from chronic inhalation exposure to workers:

- Processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing);
- Processing – repackaging – (wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing); and
- Disposal.

EPA determined that the following COU significantly contributes to unreasonable risk of injury to human health due to both non-cancer and cancer risks from intermediate and chronic inhalation exposure to ONUs:

- Processing – repackaging – (wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing).

EPA determined that the following 19 COUs do *not* contribute significantly to the unreasonable risk of injury of 1,3-butadiene to human health or the environment:

- Processing – incorporation into formulation, mixture, or reaction product – intermediate (petrochemical manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – other (oil and gas drilling, extraction, and support activities);
- Distribution in commerce;
- Industrial use – adhesives and sealants;
- Commercial use – fuels and related products;
- Commercial use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);
- Commercial use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);
- Commercial use – synthetic rubber;
- Commercial use – furniture and furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles;
- Commercial use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft);
- Commercial use – other use – laboratory chemicals;
- Commercial use – lubricants and lubricant additives;
- Commercial use – paints and coatings;
- Commercial use – adhesives and sealants;
- Consumer use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);
- Consumer use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);
- Consumer use – synthetic rubber;
- Consumer use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles; and
- Consumer use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft).

The draft risk evaluation for 1,3-butadiene was released for public comment and peer reviewed by the Science Advisory Committee on Chemicals (SACC) on April 1 to 4, 2025. This final risk evaluation takes into consideration input from the public and recommendations received from SACC**. In this risk evaluation, EPA has determined that 1,3-butadiene presents an unreasonable risk of injury to**

human health. As a next step, EPA will initiate regulatory action under TSCA section 6(a) to the extent necessary so that 1,3-butadiene no longer presents an unreasonable risk.

Key Updates to the Risk Evaluation for 1,3-Butadiene

Following the 2024 release of the *Draft Risk Evaluation for 1,3-Butadiene*, EPA made the following key updates to this completed risk evaluation:

1. Revised and detailed tiered approach analysis was used for the general population risk estimates.
2. Aggregate non-cancer analysis was added to the general population risk estimates.
3. HEM modeling using NEI 2017 and 2020 release data was added to the general population risk estimates.
4. Semi-quantitative exposure and risk analysis was added to the consumer exposure and risk sections.
5. Screening for potential risk to terrestrial organisms via ambient air exposure was added to the environmental risk assessment.
6. Maximum likelihood estimation (MLE) was used to estimate the central tendency and high-end of occupational exposure data where a majority of the dataset was below the method's limit of detection (for those without enough measured data to use MLE, the substitution method of handling non-detect data remained the same as it was in the draft).
7. The new OES of Plastics and rubber polymerization was added to the assessment, and new occupational exposure estimates were found using a variety of directly applicable studies from systematic review.
8. More details on PPE common in the workplace were added to the occupational exposure discussion.
9. Bladder cancer was combined with leukemia to derive inhalation unit risks.
10. Exposure factors and adjustments in hazard values and exposure estimates were clarified and explained.

1 INTRODUCTION

EPA has evaluated 1,3-butadiene (Chemical Abstracts Service Registry Number [CASRN] 106-99-0) under the Toxic Substances Control Act (TSCA). 1,3-Butadiene is a colorless gas with a total production volume (PV) in the United States between 1 and 5 billion pounds (lb). 1,3-Butadiene is produced from petrochemical processing and is used to aid in petrochemical manufacturing. It is primarily used to produce plastic and rubber products. This involves polymerization of 1,3-butadiene with itself or with other monomers, which are then incorporated into various rubber and plastic articles. These synthetic rubbers, resins, and latex are used to manufacture tires, other rubber components, and plastic materials. 1,3-Butadiene polymers are also used as viscosity agents in several formulations for adhesives, lubricants, and paints and coatings. These polymerization products, which are a polymer form of 1,3-butadiene, are also referred to as 1,3-butadiene by some chemical safety data sheets (SDSs). This risk assessment covers only the monomer form of 1,3-butadiene.

Figure 1-1 describes the major inputs, phases, and outputs/components of the TSCA risk evaluation process (accessed December 8, 2025), from scoping to releasing the final risk evaluation. Sections 2, 2.1, and 2.2 provide the scope of the risk evaluation, including PV, life cycle diagram (LCD), conditions of use (COUs) under TSCA, and conceptual models used for 1,3-butadiene. Sections 2.3 and 2.4 provide an overview of the systematic review process and the organization of this risk evaluation, respectively.

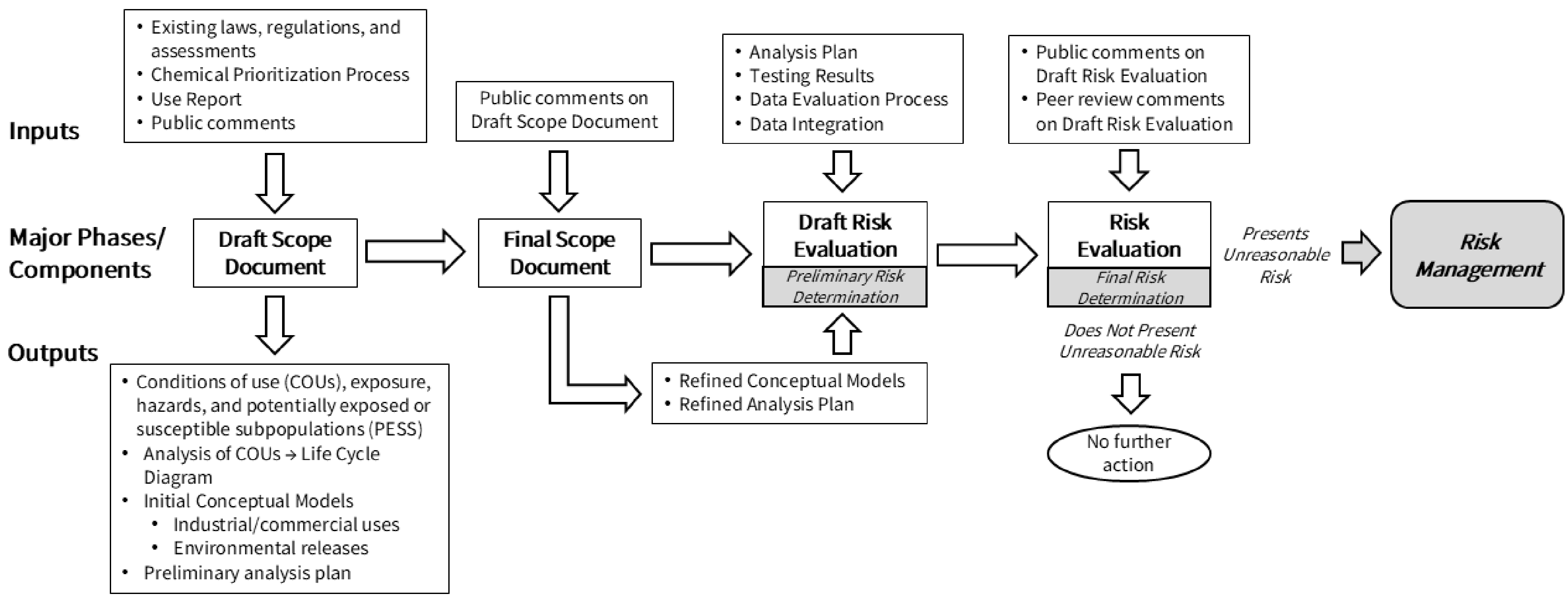

Figure 1-1. TSCA Existing Chemical Risk Evaluation Process

2 SCOPE OF THE RISK EVALUATION

EPA designated 1,3-butadiene as a high priority substance for risk evaluation in December 2019 and followed, in 2020, with the *Final Scope of Risk Evaluation for 1,3-Butadiene; CASRN 106-99-0* (also called the "final scope document") (U.S. EPA, 2020c). In alignment with the final scope document's Analysis Plan, EPA evaluated all reasonably available physical and chemical properties, environmental fate, and environmental release data and determined that air is the major exposure pathway for 1,3-butadiene. The Agency evaluated risk to human and environmental populations for 1,3-butadiene. Specifically for human populations, EPA quantitatively evaluated risk to (1) workers and occupational non-users (ONUs) via the inhalation route described in Section 5.3.2, and (2) the general population via inhalation route in Section 5.3.4. Additionally, EPA considered PESS in Section 5.3.5. For environmental populations, the Agency qualitatively assessed risks via water, sediment, and air to aquatic and terrestrial species in Sections 6.3.2 and 6.3.3, respectively.

EPA identified literature with human health hazards via the inhalation route of exposure. Furthermore, as expected based on the determination of air as the major pathway of exposure, the Agency did not identify literature on human health hazards via the oral or dermal routes of exposure. EPA also did not find literature reporting hazards to aquatic or terrestrial organisms. EPA/OPPT identified several inhalation epidemiological studies describing a single cohort of styrene-butadiene rubber (SBR) occupational workers. Some of the studies that used this occupational cohort study were included in the EPA Integrated Risk Information System (IRIS) *Health Assessment of 1,3-Butadiene* (U.S. EPA, 2002b). Using the occupational cohort data, OPPT re-evaluated and revised the inhalation unit risk (IUR) for cancer that was published by IRIS in 2002. All human health hazard and exposure values were binned into one of the following four duration categories, corresponding to human exposure scenarios for risk estimation:

- acute (single dose or exposure to an air concentration for no more than 24 consecutive hours);
- intermediate (a repeated dosing ranging anywhere from a few days to less than 10% of lifetime, typically from short-term or subchronic hazard studies and applied as average 30-day exposure for occupational scenarios);
- chronic non-cancer (repeated dosing covering greater than 10% of lifetime); and
- chronic/lifetime cancer (repeated dosing averaged over the relevant chronic period up to a full lifetime).

EPA used reasonably available information, defined in 40 CFR 702.33, in a fit-for-purpose approach to develop a risk evaluation that relies on the best available science and is based on the weight of scientific evidence. The Agency evaluated the quality of methods and reporting or results of the individual studies using the evaluations strategies described in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called the "2021 Systematic Review Protocol") (U.S. EPA, 2021a) and *Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2025aj), or as otherwise noted in the relevant technical support documents (TSDs). (See Appendix C for a complete list of all TSDs and supplemental files for this TSCA risk evaluation.)

2.1 Life Cycle and Production Volume

The LCD in Figure 2-1 depicts the COUs that are within the scope of this risk evaluation during various life cycle stages, including Manufacture and Import; Processing; Distribution; Industrial, Commercial, and Consumer Use; and Disposal. The LCD has been updated since its original inclusion in the final scope document (U.S. EPA, 2020c). A complete list and explanation of updates made to COUs for 1,3-butadiene from the final scope document to this finalized risk evaluation is provided in Appendix D.

The LCD 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. The information in the LCD is grouped according to the Chemical Data Reporting (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) (40 CFR part 711) requires U.S. manufacturers (including importers) that manufacture/import 25,000 lb or more of a relevant chemical for commercial purposes during any calendar year to provide EPA with manufacture/import information. The Agency collects CDR data approximately every 4 years with the latest collections occurring in 2020. The *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r) contains additional descriptions (*e.g.*, process descriptions, worker activities, process flow diagrams) for each manufacturing, processing, use, and disposal category.

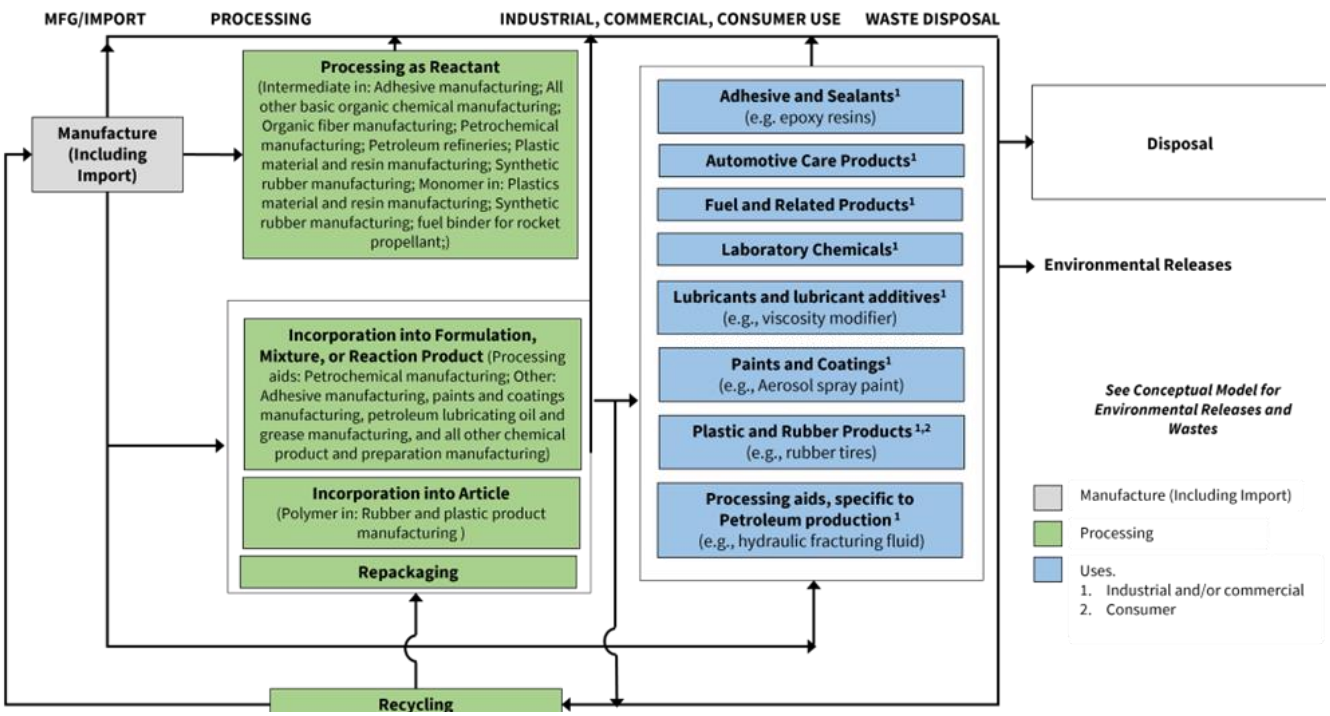

Figure 2-1. 1,3-Butadiene Life Cycle Diagram

Activities related to distribution were assessed as part of each relevant use (*e.g.*, loading and unloading that occurs at a manufacturing site) will be addressed with the manufacturing use. For any distribution in commerce activities not associated with another use, EPA assessed releases and exposures by reviewing incident reports related to 1,3-butadiene distribution within U.S. Department of Transportation (DOT) and National Response Center (NRC) databases.

The PV for 1,3-butadiene in 2016 ranged between 1 billion and 5 billion lb (U.S. EPA, 2020a) and remained unchanged in 2019 based on the latest 2020 CDR data. EPA described PV as a range to protect data claimed as confidential business information (CBI). For the 2016 and 2020 CDR cycles, collected data included the company name, volume of each chemical manufactured/imported, the number of workers at each site, and information on whether the chemical was used in the commercial, industrial, and/or consumer sector(s).

1,3-Butadiene is a monomer that is primarily used in the production of a wide range of polymers and copolymers. It is also used as an intermediate in the production of several chemicals. Due to a large majority of the total manufacturing and import volume being indicated as CBI by reporting sites, EPA did not have the ability to specify the percent of PV for each occupational exposure scenario (OES) based on CDR but instead relied on industry submitted data from the American Chemistry Council (ACC) to estimate relative percentages of use for 1,3-butadiene. ACC reported in 2022 (Figure 2-2) that roughly 63 to 69 percent of 1,3-butadiene PV goes toward the production of polymers and copolymers, such as polybutadiene and SBR, and roughly 26 to 32 percent of 1,3-butadiene PV goes toward the production of intermediate chemicals, such as adiponitrile and chloroprene. The "Other" category comprised all remaining uses of 1,3-butadiene, which may include use in formulations or as a laboratory chemical. Due to the limitations in reporting, these estimates may not fully reflect actual use and each OES may comprise a smaller or larger percentage of the overall PV of 1,3-butadiene.

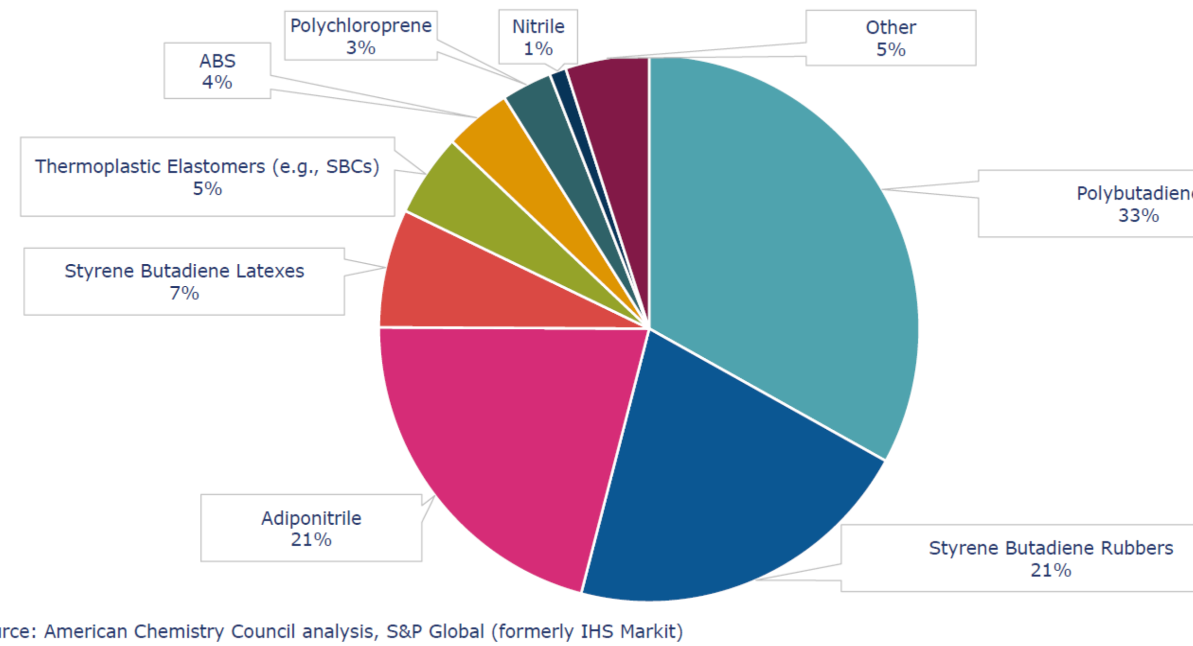

Figure 2-2. Percentage of 1,3-Butadiene Production Volume by Use

2.2 Conditions of Use Included in the Risk Evaluation

The *Final Scope of the Risk Evaluation for 1,3-Butadiene; CASRN 106-99-0* (U.S. EPA, 2020b) identified and described the life cycle stages, categories, and subcategories that comprise COUs that EPA planned to consider in the risk evaluation. 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 document, though as noted previously (see Appendix D), 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.

EPA only evaluated risks resulting from exposure to 1,3-butadiene from facilities that use, manufacture, or process 1,3-butadiene under industrial and/or commercial COUs subject to TSCA and the products resulting from such manufacture and processing. Human or environmental exposure to 1,3-butadiene from other sources (*e.g.*, vehicle exhaust, tobacco smoke, woodburning) were not evaluated or taken into account by EPA in reaching its determination of unreasonable risk to injury of human health (see Section 7). Each COU has a unique combination of life cycle stage, category(ies), and subcategory(ies) that describes the chemical's use. EPA has identified a total of 30 COUs for 1,3-butadiene. All COUs for 1,3-butadiene included in this risk evaluation are presented in Table 2-1 below.

Table 2-1. Categories and Subcategories of Conditions of Use Included in the Risk Evaluation

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Reference(s)/Notes
Manufacture	Domestic manufacturing	Domestic manufacturing	2020 CDR
	Importing	Importing	2020 CDR
Processing	Processing as a reactant	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing)	2020 CDR
		Monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing)	2020 CDR
	Processing – incorporation into formulation, mixture, or reaction product	Intermediate (petrochemical manufacturing)	2020 CDR
		Monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing)	2020 CDR
		Other (oil and gas drilling, extraction, and support activities)	2020 CDR
		Plasticizer (asphalt paving, roofing, and coating materials manufacturing)	2020 CDR
	Processing – incorporation into article	Monomer (rubber product manufacturing)	2020 CDR
	Repackaging	Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing	2020 CDR
	Use-non-incorporative activities	Fuel (petroleum refineries)	2020 CDR
	Recycling	Recycling	
Distribution in Commerce[d]	Distribution in commerce	Distribution in commerce	
Industrial Use	Adhesives and sealants	Adhesives and sealants, including epoxy resins	EPA-HQ-OPPT-2018-0451-0003 EPA-HQ-OPPT-2018-0451-0005

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Reference(s)/Notes
			EPA-HQ-OPPT-2018-0451-0009 EPA-HQ-OPPT-2019-0131-0022
Commercial Use	Fuels and related products	Fuel additive; vehicular or appliance fuels; cooking and heating fuels	2020 CDR
	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)	2020 CDR
	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)	2020 CDR
	Synthetic rubber	Synthetic rubber (*e.g.*, rubber tires)	2020 CDR
	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	2020 CDR
	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)	2020 CDR
	Other use	Laboratory chemicals	Sigma-Aldrich (2024)
	Lubricants and lubricant additives	Lubricant additives, including viscosity modifier	EPA-HQ-OPPT-2018-0451-0003 EPA-HQ-OPPT-2019-0131-0022
	Paints and coatings	Paints and coatings, including aerosol spray paint	EPA-HQ-OPPT-2018-0451-0003 EPA-HQ-OPPT-2019-0131-0022
	Adhesives and sealants	Adhesives and sealants, including epoxy resins	EPA-HQ-OPPT-2018-0451-0003 EPA-HQ-OPPT-2018-0451-0005 EPA-HQ-OPPT-2018-0451-0009 EPA-HQ-OPPT-2019-0131-0022
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)	2020 CDR

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Reference(s)/Notes
Consumer Use	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)	2020 CDR
	Synthetic rubber	Synthetic rubber (*e.g.*, rubber tires)	2020 CDR
	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	2020 CDR
	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)	2020 CDR
Disposal	Disposal	Disposal	

In this risk evaluation, EPA made updates to the COUs listed in the final scope document. These updates reflect the Agency's improved understanding of the COUs based on further outreach, public comments, and updated industry code names under the CDR for 2020. Updates included (1) additions and clarification of COUs based on new reporting in the CDR for 2020, reporting in the CDR for 2024, or information received from stakeholders; and (2) correction of typos or edits to COUs for consistency. A complete list of updates and explanations of the updates made to COUs for 1,3-butadiene from the final scope document to this risk evaluation is provided in Appendix D. Table 2-1 presents the revised COUs that were included and evaluated in this risk evaluation; Appendix E contains descriptions of each COU.

2.2.1 Occupational Scenarios

EPA assessed environmental releases and occupational exposures for the COUs described in Table 2-1. Each COU for 1,3-butadiene was assigned an OES that characterizes its release and exposure potential. Although named for their utility when assessing occupational exposure, these scenarios are also used when assessing environmental releases from industrial and commercial facilities. 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, EPA 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 entire population of workers and sites involved for the given OES in the United States. These results can be found in the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r).

Table 2-2 shows the mapping between the COUs from Table 2-1 and the OESs assessed in this risk evaluation. 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 COU categories and subcategories were grouped and assessed together in a single OES due to similarities in the processes or lack of data to differentiate between them; for example, Importing and Intermediate in wholesale and retail trade fuel were both assessed under the Repackaging OES. This grouping minimized repetitive assessments. In one case, the COU 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 with a total of 15 unique OESs were identified.

Table 2-2. 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; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing	Processing as a reactant
		Monomer used in polymerization process in: synthetic rubber manufacturing; plastic material and resin manufacturing	Plastics and rubber polymerization
	Processing – incorporation into formulation, mixture, or reaction product	Intermediate (petrochemical manufacturing)	Processing – incorporation into formulation, mixture, or reaction product
		Other (oil and gas drilling, extraction, and support activities)	Processing – incorporation into formulation, mixture, or reaction product
		Monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing)	Plastics and rubber compounding and converting
		Plasticizer (asphalt paving, roofing, and coating materials manufacturing)	Plastics and rubber compounding and converting
	Processing – incorporation into article	Monomer (rubber product manufacturing)	Plastics and rubber compounding and converting

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario
Processing	Repackaging	Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing	Repackaging
	Use-non-incorporative activities	Fuel (petroleum refineries)	Processing as a reactant
	Recycling	Recycling	Processing as a reactant
			Use of plastics and rubber products[e]
Distribution in Commerce	Distribution in commerce	Distribution in commerce	Distribution in commerce[d]
Industrial Use	Adhesives and sealants	Adhesives and sealants, including epoxy resins	Application of adhesives and sealants
Commercial Use	Fuels and related products	Fuel additive; vehicular or appliance fuels; cooking and heating fuels	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)	
	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
	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
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.
- 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 COU appear in the LCD, reflect CDR codes, and broadly represent COUs of 1,3-butadiene in industrial and/or commercial settings.

[c] These subcategories reflect more specific COUs of 1,3-butadiene.
- "Incorporation into article – polymer in rubber product manufacturing," as reported to the 2016 CDR, is a COU that EPA considered as manufacturing of articles involving butadiene-derived polymers, including plastics such as acrylonitrile-butadiene-styrene (ABS) 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

Life Cycle Stage[a]	Category[b]	Subcategory[c]	Occupational Exposure Scenario
Transportation (DOT) and National Response Center (NRC) data for incident reports pertaining to 1,3-butadiene distribution. [e] Although 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 of the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r). [f] Consumer uses are not assigned to an OES as they are not part of the occupational assessment. See Section 5.1.2 for information on the consumer exposure 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 2-3). This would be utilized in mapping release and exposure data to an OES as well as applying release modeling approaches. The table below is a summary; for more information on each OES, see the corresponding process description in the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r).

Table 2-3. 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 3 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 a reactant: intermediate COU subcategory, Use-non-incorporative activities subcategory, and part of the Recycling COU category. 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. It 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 rocket propellant manufacturing by the U.S. 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.

OES	Role/Function of 1,3-Butadiene
Plastic and rubber polymerization	This OES captures the Processing as a reactant: 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 (ABS), and nitrile rubber. This is the most common use of 1,3-butadiene.
Plastics and rubber compounding and 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 sealants	This OES captures the Industrial use of adhesives and sealants, as well as the 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 are provided.
Recycling	This OES captures part of the Disposal COU categories. There are multiple ways 1,3-butadiene can be recycled during its life cycle. 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.

OES	Role/Function of 1,3-Butadiene
Waste handling, treatment, and disposal	This OES captures part of the Disposal COU category. Each of the OESs 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 5 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. It was determined that butadiene is present in rubber products at no greater amounts that 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. Furthermore, 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.

2.2.2 Conceptual Models

Figure 2-3 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 exposures to workers and/or ONUs via inhalation. EPA evaluated activities resulting in exposures associated with distribution in commerce (*e.g.*, loading, unloading) throughout the various life cycle stages and COUs (*e.g.*, Manufacturing, Processing, Industrial Use, Commercial Use, Disposal), as well as qualitatively through a single distribution scenario.

Figure 2-4 presents the conceptual model for general population exposure pathways and hazards from environmental releases and wastes as well as ecological exposures and hazards from environmental releases and wastes.

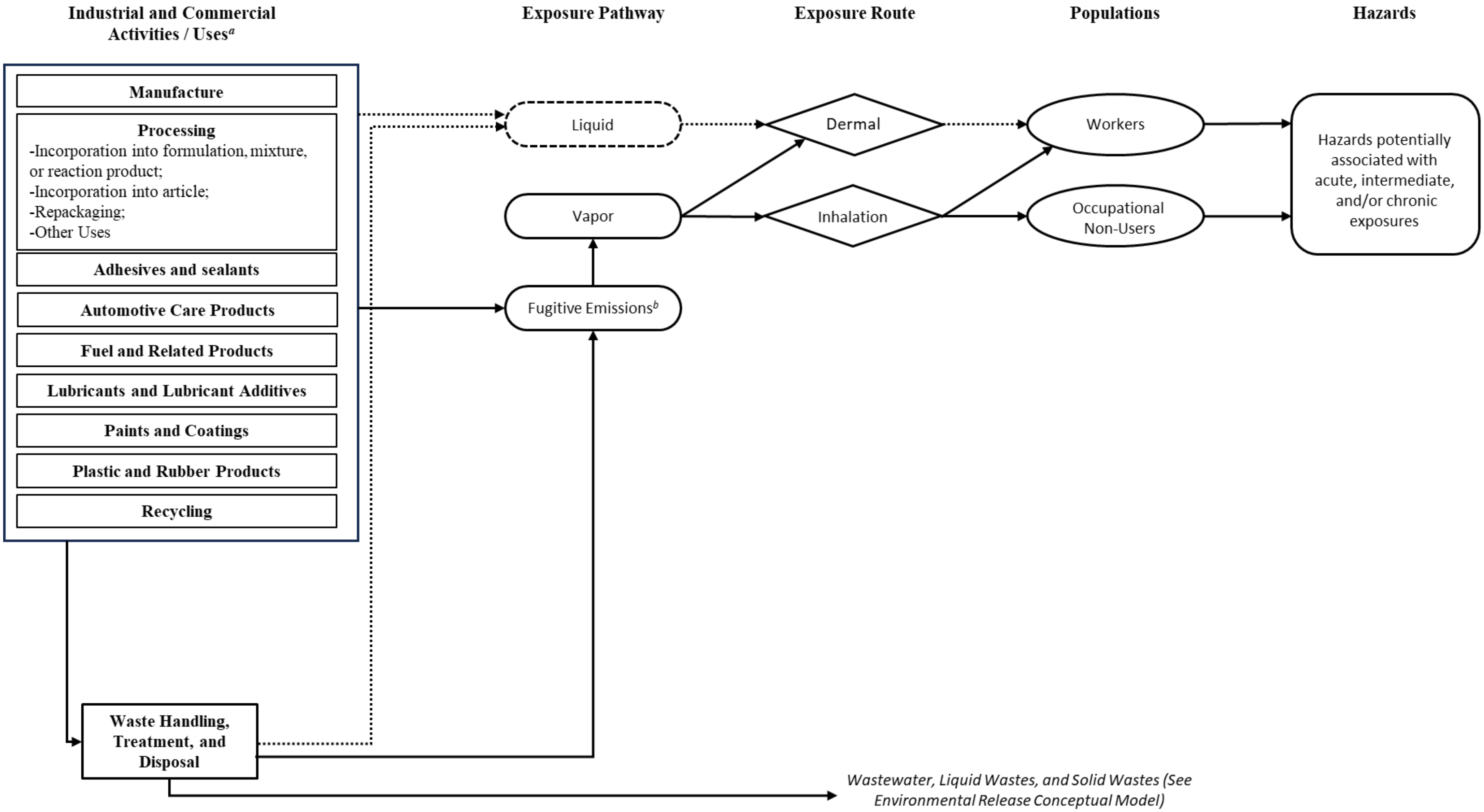

Figure 2-3. 1,3-Butadiene Conceptual Model for Industrial and Commercial Activities and Uses: Potential Exposures and Hazards

[a] Some products are used in both industrial and commercial applications. See Table 2-1 for categories and subcategories of COUs.

[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.

Solid lines represent a quantitative assessment while broken lines represent a qualitative assessment.

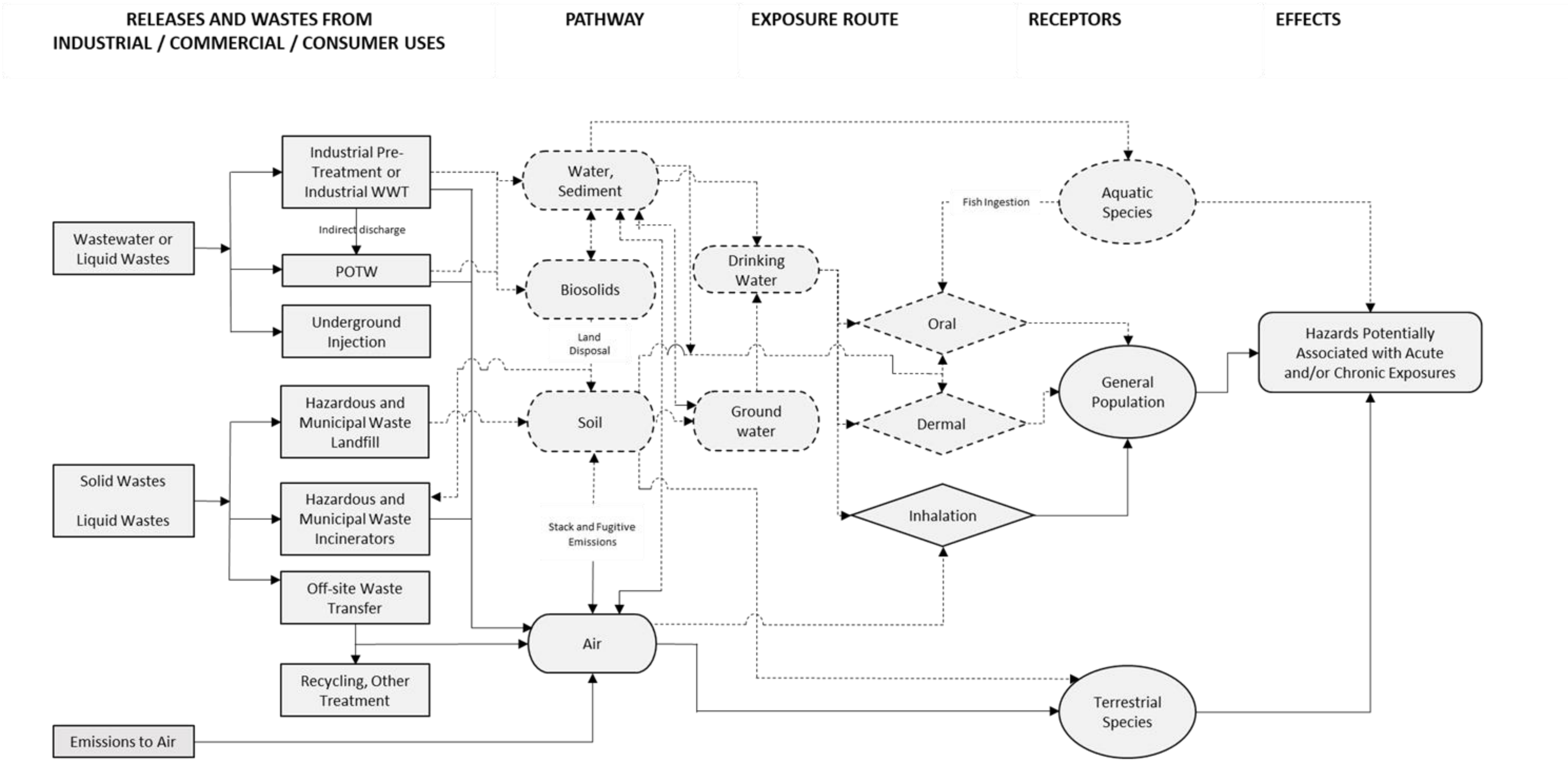

Figure 2-4. 1,3-Butadiene Conceptual Model for Environmental Releases and Wastes: Potential Environmental and General Population Exposures and Hazards

The conceptual model presents the exposure pathways, exposure routes, and hazards to human and ecological populations from releases and wastes from industrial and commercial uses of 1,3-butadiene.

Solid lines represent a quantitative assessment while broken lines represent a qualitative assessment.

2.2.3 Populations

Based on the conceptual models presented in Section 2.2.2, EPA evaluated risk to environmental and human populations. Environmental exposure and risks were qualitatively evaluated for aquatic and terrestrial species in Section 1. Human health risks were evaluated for all exposure scenarios, as applicable based on reasonably available exposure and hazard data as well as the relevant populations for each. Human populations assessed included the following:

- workers and ONUs, including average adults and women of reproductive age; and
- general population exposed to environmental releases, including infants, children, youth, and adults.

2.2.4 Potentially Exposed or Susceptible Subpopulations

TSCA section 6(b)(4)(A) requires that risk evaluations "determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other nonrisk 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." TSCA section 3(12) states that "the term 'potentially exposed or susceptible subpopulation' (PESS) means a group of individuals within the general population identified by the Administrator who, due to either greater susceptibility or greater exposure, may be at greater risk than the general population of adverse health effects from exposure to a chemical substance or mixture, such as infants, children, pregnant women, workers, or the elderly."

This risk evaluation considers PESS throughout the human health risk assessment (Section 5.3.5)—including throughout the exposure assessment, hazard identification, and dose-response analysis supporting this assessment. In addition, see Section 9.2 in the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y) for details on how EPA considered evidence of greater susceptibility among subpopulations.

2.3 Systematic Review

EPA/OPPT applies systematic review principles in the development of risk evaluations under the amended TSCA. TSCA section 26(h) requires EPA to use scientific information, technical procedures, measures, methods, protocols, methodologies, and models consistent with the best available science and base decisions under section 6 on the weight of scientific evidence.

To meet the TSCA section 26(h) science standards, EPA used the TSCA systematic review process described in the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called the "2021 Draft Systematic Review Protocol") (U.S. EPA, 2021a) and in the *Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2025aj). Systematic review supports the risk evaluation in that data searching, screening, evaluation, extraction, and evidence integration are used to develop the exposure and hazard assessments based on reasonably available information. EPA defines "reasonably available information" to mean information that the Agency possesses or can reasonably obtain and synthesize for use in risk evaluations, considering the deadlines for completing the evaluation (40 CFR 702.33).

The systematic review process is briefly described in Figure 2-5 below. Additional information regarding these steps is provided in the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a) and the *Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2025aj). The latter provides additional information on the steps in the systematic review process—including literature inventory trees and evidence maps for each discipline (*e.g.*, human health hazard) containing results of the literature search and screening, as well as sections summarizing data evaluation, extraction, and evidence integration.

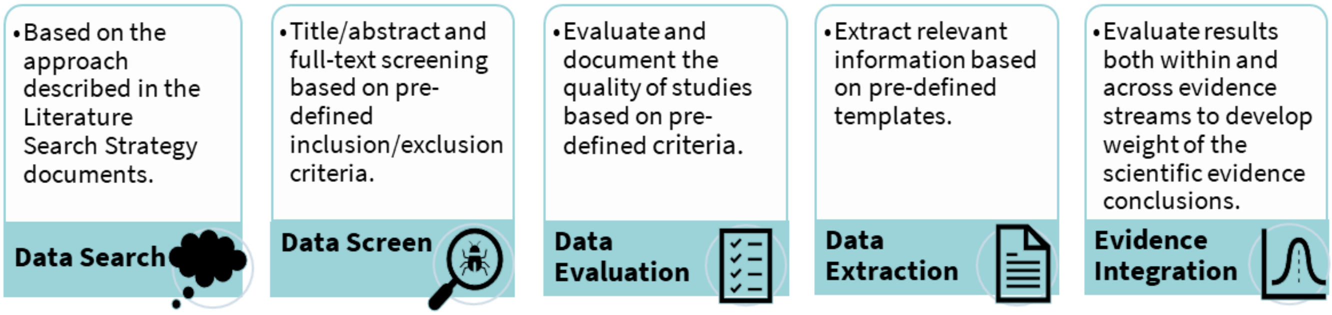

Figure 2-5. Diagram of the Systematic Review Process

The Agency also identified key assessments not identified from systematic review, conducted by other EPA programs and other U.S. and international organizations. Depending on the source, these assessments may include information on COUs (or the equivalent), hazards, exposures, and PESS. EPA initially incorporated and considered all reasonably available information through a literature search covering all data sources through September 2019. Additionally, more recent data sources were incorporated as they became available or were identified by EPA through updates to the literature pool (*e.g.*, 2021 Toxics Release Inventory [TRI], (Sathiakumar et al., 2021b)). This final risk evaluation also considers all references suggested through peer review and public comments. For more details, see the *Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2025aj).

2.4 Organization of the Risk Evaluation

Figure 2-6 illustrates the organization the risk evaluation and related TSDs for 1,3-butadiene (see also Appendix C). This risk evaluation for 1,3-butadiene includes five additional major sections and several appendices:

- Section 3 summarizes basic physical and chemical characteristics as well as the fate and transport of 1,3-butadiene.
- Section 4 includes an overview of releases and concentrations of 1,3-butadiene in the environment.
- Section 5 presents the human health risk assessment, including the exposure, hazard, and risk characterization based on the COUs.
    - It includes a discussion of PESS based on both greater exposure and/or susceptibility, as well as a description of aggregate and sentinel exposures. It also discusses assumptions and uncertainties and how they potentially impact the strength of the evidence of the risk evaluation.
    - Section 5.3.5 provides considerations for PESS.
- Section 6 provides a discussion and analysis of the environmental risk assessment, including the environmental exposure and risk characterization based on the COUs for 1,3-butadiene.
    - It also discusses assumptions and uncertainties and how they potentially impact the strength of the evidence of the risk evaluation.
- Section 7 presents EPA's proposed determination of whether the chemical presents an unreasonable risk to human health or the environment as a whole-chemical approach and under the assessed COUs.

- Appendix A provides a list of key abbreviations and acronyms used throughout this risk evaluation.
- Appendix B provides a summary of the federal, state, and international regulatory history of 1,3-butadiene.
- Appendix C includes a list and citations for all TSDs and supplemental files included in the risk evaluation for 1,3-butadiene.
- Appendix D provides a summary of updates made to COUs for 1,3-butadiene from the final scope document to this risk evaluation.
- Appendix E provides descriptions of the 1,3-butadiene COUs evaluated by EPA.
- Appendix F provides the occupational exposure value (OEV) for 1,3-butadiene that was derived by EPA.
- Appendix H provides additional information, tables and figures for general population risks.

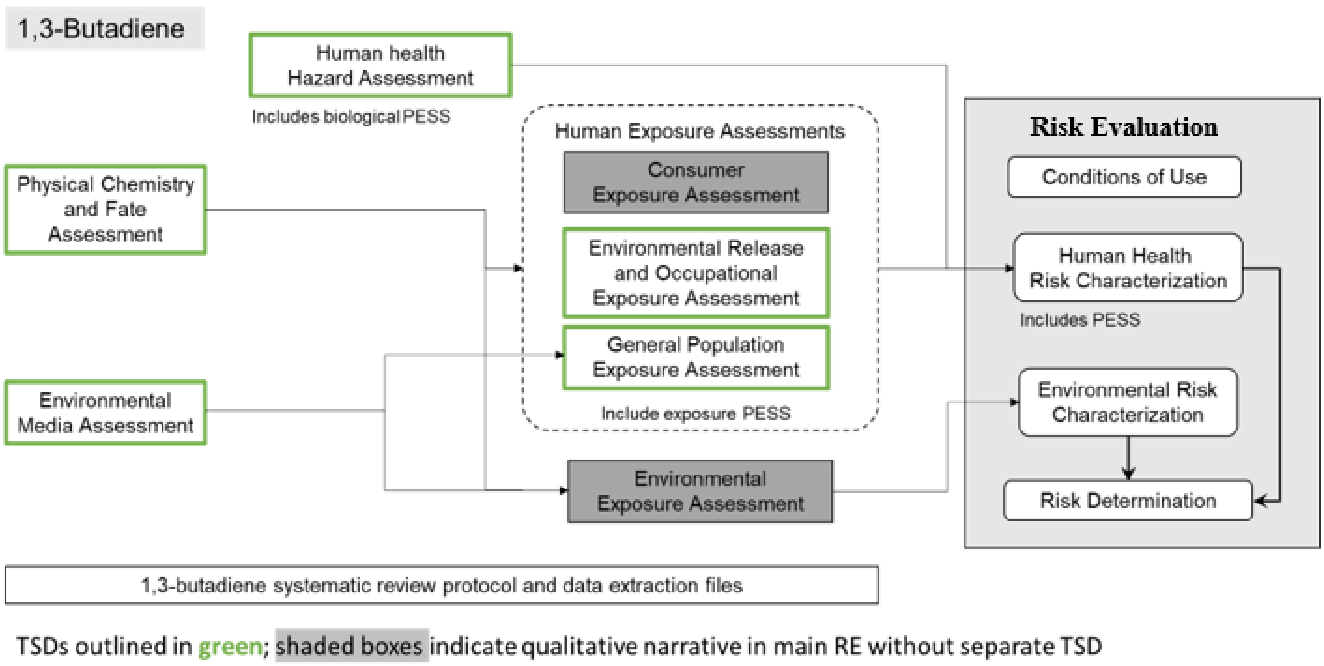

Figure 2-6. Document Map of the Risk Evaluation for 1,3-Butadiene

3 CHEMISTRY AND FATE AND TRANSPORT OF 1,3-BUTADIENE

Physical and chemical properties determine the behavior and characteristics of a chemical that inform its COUs, environmental fate and transport, potential toxicity, exposure pathways, routes, and hazards. Environmental fate and transport include environmental partitioning, accumulation, degradation, and transformation processes. Environmental transport is the movement of the chemical within and between environmental media such as air, water, soil, and sediment. Thus, understanding the environmental fate of 1,3-butadiene informs both the specific exposure pathways and potential human and environmental exposed populations that EPA considered in this risk evaluation. This section summarizes the physical and chemical properties, and environmental fate and transport of 1,3-butadiene.

3.1 Summary of Chemistry and Environmental Fate and Transport

1,3-Butadiene is a colorless gas with a mildly aromatic or gasoline-like odor (Rumble, 2018b; NLM, 2003). It is moderately soluble in aqueous systems, with a water solubility of 735 mg/L (NLM, 2003). It is a highly volatile organic compound (VOC), with a −4.54 °C boiling point and a vapor pressure of 1,900 mm Hg (NIST, 2022; National Toxicology Program (NTP), 1993).

With greater than 90 percent of 1,3-butadiene released to air as reported by EPA's TRI Program (see *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)), EPA expects air to be the major environmental compartment for 1,3-butadiene. 1,3-Butadiene will degrade in air rapidly (half-life of 1.6–2.6 hours) by reaction with photochemically produced hydroxyl radicals (·OH) in the atmosphere during the day to form formaldehyde and acrolein (Khaled et al., 2019; Vimal, 2008; Klamt, 1993). It will also react more slowly with nitrate radicals (NO_3·) and ozone in the atmosphere, with half-lives of 3 to 9 hours and 34 hours, respectively (U.S. EPA, 2012b; Zhao et al., 2011; Andersson and Ljungström, 1989). Based on an estimated octanol-air partition coefficient (K_{OA}) of 31.5 to 33.7 (U.S. EPA, 2012b), 1,3-butadiene is not expected to associate strongly with airborne particulates; therefore, it is not expected to undergo dry deposition. Overall, 1,3-butadiene in the atmosphere is expected to remain largely in the vapor phase, where it is not expected to persist or undergo long-range transport.

TRI reported very low releases of 1,3-butadiene to water (U.S. EPA, 2025r). Based on a Henry's Law constant of 0.076 atm·m^3/mol at 25 °C (Rumble, 2018a) and a vapor pressure of 1,900 mm Hg at 20 °C (National Toxicology Program (NTP), 1993), volatilization from water surfaces is expected to be a significant process for 1,3-butadiene; thus, mitigating its persistence in aquatic environments. 1,3-Butadiene is not expected to bioaccumulate in aquatic organisms given an estimated bioconcentration factor of 9.55 L/kg (U.S. EPA, 2012b). Overall, 1,3-butadiene is primarily released to and will generally partition to air where it has low persistence potential. A detailed description of the selected physical and chemical and fate values and other fate analyses are contained in the *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae). An illustrated summary of the fate assessment for 1,3-butadiene is shown in Figure 3-1.

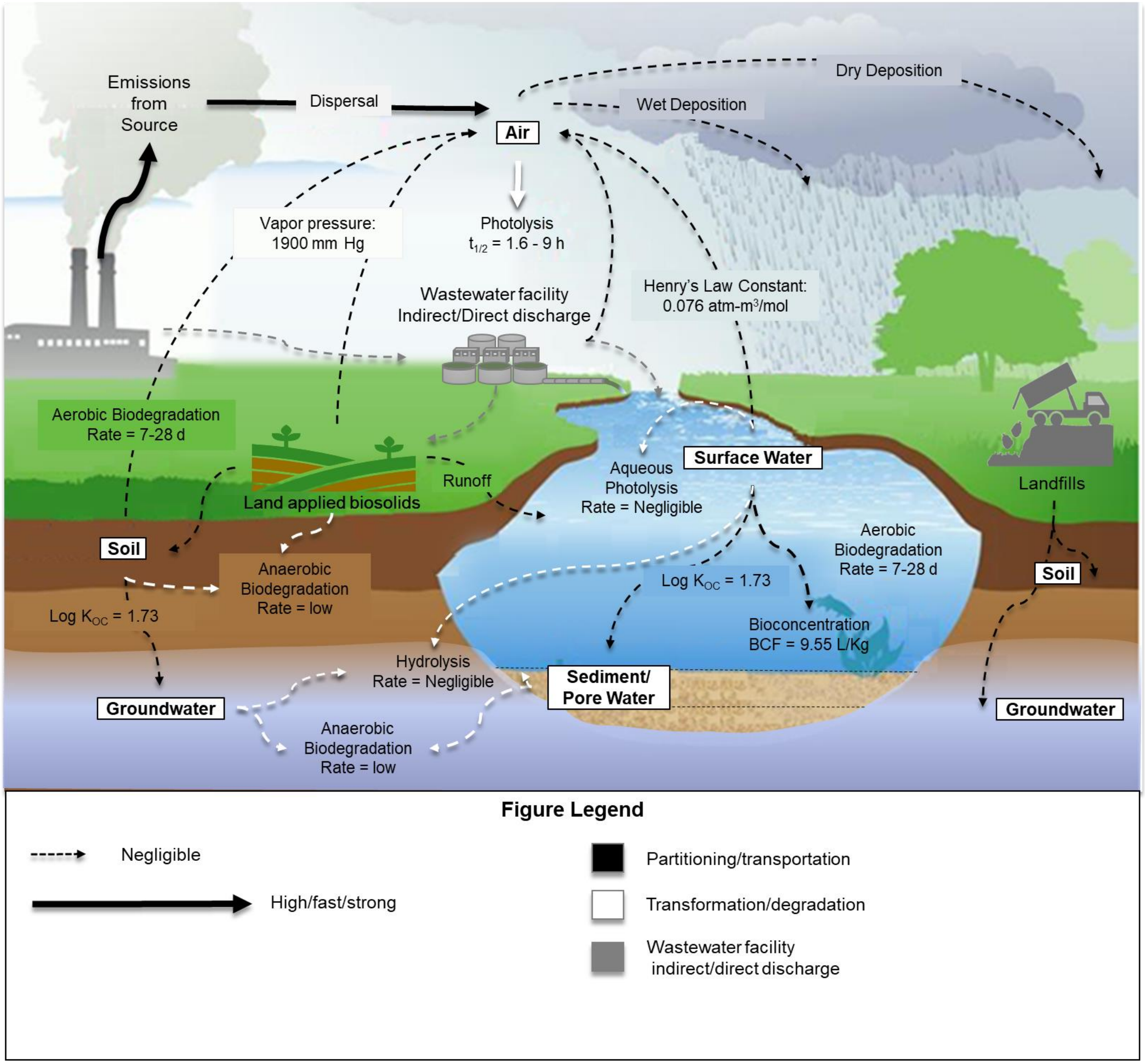

Figure 3-1. Transport, Partitioning, and Degradation of 1,3-Butadiene in the Environment

The diagram depicts the distribution (grey arrows), transport, and partitioning (black arrows), as well as the transformation and degradation (white arrows) of 1,3-butadiene in the environment. The width of the arrow is a qualitative indication of the likelihood that the indicated partitioning will occur or the rate at which the indicated degradation will occur (*i.e.*, wider arrows indicate more likely partitioning or more rapid degradation).

3.2 Weight of Scientific Evidence Conclusions for Chemistry, Fate, and Transport

The general confidence in the physical and chemical properties for 1,3-butadiene is robust. Measured data were identified from high-quality studies for all physical and chemical properties. Evaluation of the weight of scientific evidence for the fate and transport of 1,3-butadiene is shown below and is based on categorization described in the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a).

Given consistent results from numerous high-quality studies, there is robust confidence that 1,3-butadiene will

- photodegrade rapidly in air to yield formaldehyde and acrolein;
- not partition to organic matter in water; and
- not hydrolyze significantly in water.

Given limited results from high-quality studies, there is moderate confidence that 1,3-butadiene will

- biodegrade rapidly in aerobic river water or wetland sediment;
- biodegrade rapidly in aerobic soil;
- not sorb to soil/sediment particles;
- not biodegrade rapidly in anaerobic sediment;
- be degraded by methane-utilizing bacteria to form 1,2-epoxybutene; and
- not bioaccumulate in fish.

4 RELEASES AND CONCENTRATIONS OF 1,3-BUTADIENE IN THE ENVIRONMENT

EPA estimated environmental releases and concentrations of 1,3-butadiene. Section 4.1 summarizes the approach and methodology for estimating release and presents estimates of environmental releases. Section 4.2 summarizes the approach and methodology for estimating environmental concentrations as well as a summary of concentrations of 1,3 butadiene in the environment. Complete descriptions of these analyses are presented in the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r) (environmental releases), and the *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u) (environmental concentrations).

4.1 Summary of Environmental Releases

4.1.1 Industrial and Commercial

EPA's first source of information to estimate releases from each OES is programmatic databases. These databases provide annual facility releases from which daily release estimates are obtained by dividing the annual release by the number of expected release days. Once these data are obtained from the databases, each facility is mapped to one of the OESs described in Section 4.1.1. After mapping is complete, each OES may have release data from multiple facilities. These data are considered together to inform the releases that are expected to occur due to the OES. There are cases when there are few or no facilities mapped to a given OES. In these cases, gaps are filled with release modeling. For 1,3-butadiene, only one OES (Application of adhesives and sealants) required the use of release modeling due to lack of programmatic data.

The other important components of the environmental release assessment are number of release days and the number of facilities. Number of release days may be obtained through literature or through assumptions based on generic industry information—often from Emission Scenario Documents (ESDs) or Generic Scenarios (GSs). Number of facilities may be obtained through programmatic data, literature, or through assumptions and modeling based on Bureau of Labor Statistics (BLS)[1] and Statistics of U.S. Businesses (SUSB[2]) data.

4.1.1.1 Summary of Daily Environmental Release Estimates

Figure 4-1 below shows an overview for how the different assessment components and data sources feed into the daily release estimates for each OES.

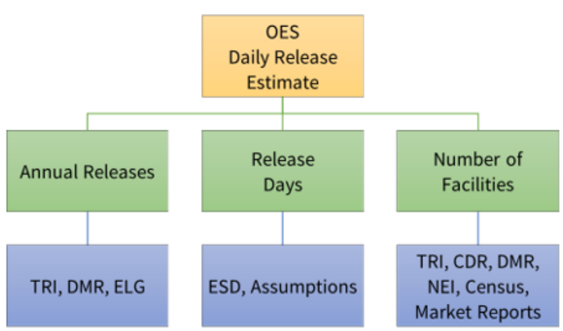

Figure 4-1. An Overview of How EPA Estimated Daily Releases for Each OES

[1] https://www.bls.gov/ (accessed December 8, 2025).
[2] https://www.Census.gov/programs-surveys/susb.html (accessed December 8, 2025).

In Table 4-1, EPA provides a summary for each of the OESs by indicating the type of release and number of facilities. The Agency provides estimates of daily and annual releases, including both central tendency and high-end values. A majority of releases of 1,3-butadiene were to air in the form of stack and fugitive releases. According to TRI between the years of 2016 and 2021 land releases contributed between one and three percent of 1,3-butadiene total releases while discharges to surface water contributed 0.1 percent or less. The OESs with the highest expected releases were Manufacturing, Plastic and rubber polymerization, and Application of adhesives and sealants. For detailed information on these procedures for estimating environmental releases, see the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r).

Releases were not quantified from commercial use in fuels and related products, which includes 1,3-butadiene used as a fuel binder for solid rocket fuels and 1,3-butadiene's presence in liquified petroleum gas (LPG) used as a fuel. Releases were not quantified for this COU because, in the case of the use as a fuel binder, this is not a use of 1,3-butadiene monomer but rather polymers created from 1,3-butadiene and other monomers. Although residual 1,3-butadiene monomer has the potential to be present in these polymers, the concentration of residual 1,3-butadiene would be minimal. Thus, the release of 1,3-butadiene from this use is negligible. With respect to LPG used as a fuel, these releases were not quantified due to (1) uncertainty in the amount of 1,3-butadiene in LPG product; (2) dispersed use of LPG product across domestic, industrial, and commercial applications; (3) inability to determine a reasonable number of use sites; and (4) predicted minimal or unquantifiable releases from connecting equipment/cylinder leaks and due to the high combustion efficiency of LPG fuel.

Releases were also not quantitatively assessed for the commercial COUs covered by the OES of Use of plastics and rubber products and Use of lubricants and greases. Reasonably available evidence suggests that 1,3-butadiene monomer does not exist at concentrations above 6.6 ppm in rubber products or above quantifiable levels in lubricants and greases. In EPA's investigations, 1,3-butadiene indicated in relevant SDSs or other product reports referred either to upstream steps or to reacted polymeric forms.

Table 4-1. Summary of Environmental Releases of 1,3-Butadiene by Occupational Exposure Scenarios

Occupational Exposure Scenario (OES)	Estimated Annual Release Range Across Sites (kg/site-yr)		Type of Discharge[b], Air Emission[c], or Transfer for Disposal[d]	Estimated Daily Release Range Across Sites (kg/site-day) [e]		Number of Facilities	Source(s) [g]
	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	40	NEI
	1,142	3.3E04	Stack air	3.3	95	39	TRI
	665	1.7E04	Stack air	2.0	46	34	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	74	NEI
	21	1,970	Stack air	5.9E−02	5.6	24	TRI
	23	1,127	Stack air	7.4E−02	3.2	51	NEI
	2.3	6.8	Land	6.5E−03	1.9E−02	2	TRI
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	5.1	54	TRI
	60	2774	Fugitive air	0.17	7.6	57	NEI
	94	4,419	Stack air	0.27	13	53	TRI
	56	7281	Stack air	0.16	20	54	NEI
	0.69	207	Land	2.0E−03	0.59	13	TRI

Occupational Exposure Scenario (OES)	Estimated Annual Release Range Across Sites (kg/site-yr)		Type of Discharge[b], Air Emission[c], or Transfer for Disposal[d]	Estimated Daily Release Range Across Sites (kg/site-day) [e]		Number of Facilities	Source(s) [g]
	Central Tendency	High-End[a]		Central Tendency	High-End		
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	114	NEI
	56	1,349	Stack air	0.22	5.4	49	TRI
	12	455	Stack air	3.7E−02	1.2	107	NEI
	27	1.0E04	Land	0.11	40	4	TRI
Plastics and rubber polymerization	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
	375	8339	Fugitive air	1.7	23	44	NEI
	903	1.7E04	Stack air	3.0	56	33	TRI
	122	9233	Stack air	0.41	34	57	NEI
	49	366	Land	0.16	1.2	7	TRI
Plastics and rubber compounding and converting	113	215	Fugitive air	0.38	0.72	2	TRI
	0.57	18	Fugitive air	1.9E−03	7.3E−02	50	NEI
	113	215	Stack air	0.38	0.72	2	TRI
	6	46	Stack air	1.9E−02	0.14	57	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	4	NEI
	37	53	Stack air	0.1	0.14	1	NEI
Application of paints and coatings	0.2	31	Fugitive air	5.7E−04	0.12	14	NEI
	13	370	Stack air	4.4E−02	1.1	19	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	Environ-mental release modeling
	589	2,878	Incineration or landfill	2.7	15		
	2.7E04	1.2E05	Air, incineration, or landfill	124	631		

Occupational Exposure Scenario (OES)	Estimated Annual Release Range Across Sites (kg/site-yr)		Type of Discharge[b], Air Emission[c], or Transfer for Disposal[d]	Estimated Daily Release Range Across Sites (kg/site-day) [e]		Number of Facilities	Source(s) [g]
	Central Tendency	High-End[a]		Central Tendency	High-End		
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
	4.5	460	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	49	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	251	NEI
	5,781	6,226	Land	23	25	2	TRI
Distribution in commerce	N/A [f]						

NEI = National Emissions Inventory; TRI = Toxics Release Inventory
[a] "High-end" are defined as 95th percentile releases
[b] Direct discharge to surface water and indirect discharges to wastewater treatment (WWT) or publicly owned treatment works (POTWs) 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-butadiene within an OES.
[f] While EPA considers distribution of commerce activities such as loading and unloading as part of each use' OES, EPA also reviewed NRC data and DOT data for the 2016–2021 calendar years for incident reports pertaining to distribution of 1,3-butadiene (DOT Hazmat Incident Report Data, (NRCe, 2009)).
[g] TRI data from years 2016–2021, and National Emissions Inventory (NEI) data from years 2017 and 2020

4.1.1.2 Weight of Scientific Evidence Conclusions for Environmental Releases from Industrial and Commercial Sources

Table 4-2 summarizes the weight of scientific evidence ratings for each media of release for each OES. For more detail, see the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r).

Table 4-2. Summary of the Weight of Scientific Evidence Ratings for Environmental Releases of 1,3-Butadiene

Occupational Exposure Scenario (OES)	Release Media	Reported Data[a]	Data Quality Ratings for Reported Data	Modeling	Data Quality Ratings for Modeling[b]	Weight of Scientific Evidence Conclusion
Manufacturing	Surface water	✓	H	✗	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	✗	N/A	
	Fugitive air (TRI)	✓	H	✗	N/A	
	Stack air (NEI)	✓	M	✗	N/A	
	Stack air (TRI)	✓	H	✗	N/A	
	Land	✓	H	✗	N/A	
Repackaging	Surface water	✓	H	✗	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	✗	N/A	
	Fugitive air (TRI)	✓	H	✗	N/A	
	Stack air (NEI)	✓	M	✗	N/A	
	Stack air (TRI)	✓	H	✗	N/A	
	Land	✓	H	✗	N/A	
Processing as a reactant	Surface water	✓	H	✗	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	✗	N/A	
	Fugitive air (TRI)	✓	H	✗	N/A	
	Stack air (NEI)	✓	M	✗	N/A	
	Stack air (TRI)	✓	H	✗	N/A	
	Land	✓	H	✗	N/A	
Processing – incorporation into formulation, mixture, or reaction product	Surface water	✓	H	✗	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	✗	N/A	
	Fugitive air (TRI)	✓	H	✗	N/A	
	Stack air (NEI)	✓	M	✗	N/A	
	Stack air (TRI)	✓	H	✗	N/A	

Occupational Exposure Scenario (OES)	Release Media	Reported Data[a]	Data Quality Ratings for Reported Data	Modeling	Data Quality Ratings for Modeling[b]	Weight of Scientific Evidence Conclusion
	Land	✓	H	✘	N/A	
Plastics and rubber polymerization	Surface water	✓	H	✘	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	✘	N/A	
	Fugitive air (TRI)	✓	H	✘	N/A	
	Stack air (NEI)	✓	M	✘	N/A	
	Stack air (TRI)	✓	H	✘	N/A	
	Land	✓	H	✘	N/A	
Plastics and rubber compounding and converting	Surface water	✓	H	✘	N/A	Moderate to Robust
	Fugitive air (NEI)	✓	M	✘	N/A	
	Fugitive air (TRI)	✓	H	✘	N/A	
	Stack air (NEI)	✓	M	✘	N/A	
	Stack air (TRI)	✓	H	✘	N/A	
	Land	✓	H	✘	N/A	
Use of laboratory chemicals	Fugitive air (NEI)	✓	M	✘	N/A	Moderate
	Stack air (NEI)	✓	M	✘	N/A	
Application of paints and coatings	Fugitive air (NEI)	✓	M	✘	N/A	Moderate
	Stack air (NEI)	✓	M	✘	N/A	
Application of adhesives and sealant	Stack air (NEI)	✘	M	✓	N/A	Slight[c]
	Fugitive or stack air	✘	N/A	✓	S	
	Incineration or landfill	✘	N/A	✓	S	
	Air, incineration, or landfill	✘	N/A	✓	S	
Recycling	Surface Water	✓	H	✘	N/A	Moderate to Robust

Occupational Exposure Scenario (OES)	Release Media	Reported Data[a]	Data Quality Ratings for Reported Data	Modeling	Data Quality Ratings for Modeling[b]	Weight of Scientific Evidence Conclusion
	Fugitive Air (NEI)	✓	M	✗	N/A	
	Fugitive Air (TRI)	✓	H	✗	N/A	
	Stack Air (NEI)	✓	M	✗	N/A	
	Stack Air (TRI)	✓	H	✗	N/A	
	Land	✓	H	✗	N/A	
Waste handling, disposal, and treatment	Surface water		–		–	Moderate to Robust
	Fugitive Air (NEI)	✓	M	✗	N/A	
	Fugitive Air (TRI)	✓	H	✗	N/A	
	Stack Air (NEI)	✓	M	✗	N/A	
	Stack Air (TRI)	✓	H	✗	N/A	
	Land	✓	H	✗	N/A	

For the data quality ratings, H = high, M = medium, S = slight, N/A = not applicable
[a] Reported data includes data obtained from EPA databases (*i.e.*, TRI, NEI).
[b] Data quality ratings for models include ratings of underlying literature sources used to select model approaches and input values/distributions such as a GS/ESD used in tandem with Monte Carlo modeling.
[c] This slight rating is primarily due to the reasonableness of the product, a sealant containing up to 24% 1,3-butadiene, on which this release assessment is based. It is unlikely that 1,3-butadiene monomer would be present at the indicated concentrations of up to 24% in a non-pressurized commercial product as is stated in the SDS used in this assessment. This is due to the physical properties of 1,3-butadiene, which is a gas at room temperature and would not remain within the product at such high concentrations. The slight rating is also due to uncertainty in the representativeness of values toward the true distribution of potential releases, and the lack of chemical throughput data and number of facilities which are based on the relevant ESD and applying conservative assumptions to public comments provided to EPA. See Sections 3.10 and 6 of the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r) for more detail.

4.2 Summary of Concentrations of 1,3-Butadiene in the Environment

4.2.1 Environmental Exposure Scenarios

4.2.1.1 Air Pathway

EPA searched peer-reviewed literature for air monitoring and environmental sampling studies, as well as databases to obtain concentrations of 1,3-butadiene in air. The Agency found measured data on 1,3-butadiene in ambient air, indoor air, landfill gas, and personal exposure monitoring samples from peer-reviewed studies through systematic review. For ambient air, concentrations from five U.S. studies ranged from 0.01 to 1.91 $\mu g/m^3$. In addition, monitoring data were extracted from EPA's Ambient Monitoring Technology Information Center (AMTIC) database where 24-hour concentrations of 1,3-butadiene ranged from 0.0 to 267.3 $\mu g/m^3$. For more details, see *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q). Based on the physical and chemical properties as well as concentrations reported from databases and scientific literature, a quantitative exposure assessment was conducted for the ambient air pathway for general population. See Section 5.1.3.1 for more details.

4.2.1.2 Surface Water and Sediment Pathway

The Water Quality Portal (WQP) (U.S. EPA, 2022b)is a publicly available resource which integrates water quality data from the U.S. Geological Survey (USGS) National Water Information System (NWIS) (USGS, 2013) and the EPA Water Quality Exchange (WQX) Data Warehouse (U.S. EPA, 2019b). The NWIS database contains current and historical water data from more than 1.5 million sites across the nation. The WQX contains EPA's repository of water quality monitoring data collected by water resource management groups across the nation. The complete set of 1,3-butadiene monitoring results for surface water stored in the WQP (U.S. EPA, 2022b) was retrieved in January 2024. Without exception, all surface water samples reported 1,3-butadiene concentrations below the minimum detection limit (MDL). Based on the low reported releases to surface water (see *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)), the low solubility in water of 735 mg/L (NLM, 2003), high volatility from water, low estimated organic carbon:water partition coefficient (K_{OC}) value of 54 (U.S. EPA, 2012c), and WQP data reporting 1,3-butadiene concentrations for all surface water samples below the MDL, EPA decided to not conduct a quantitative assessment of exposure for surface water or sediment. For a detailed discussion, see *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q) and *Water Quality Portal (WQP) Monitoring Data 2004 to 2025 for 1,3-Butadiene* (U.S. EPA, 2025al).

4.2.1.3 Drinking Water Pathway

Public water systems (PWSs) are regulated under the Safe Drinking Water Act (SDWA[3]) to enforce common standards for drinking water across the country. To assess concentrations of 1,3-butadiene in water known to be distributed as drinking water, monitoring data collected by PWSs were evaluated. Concentrations of 1,3-butadiene found in finished (*i.e.*, treated) drinking water were collected from the EPA's published Third Unregulated Contaminant Monitoring Rule (UCMR3) dataset,[4] which includes samples collected between 2013 to 2015 (U.S. EPA, 2017). Based on the physical and chemical properties of 1,3-butadiene (*i.e.,* its low water solubility and high tendency to volatilize from water as well as UCMR3 data showing that 1,3-butadiene is not detected in drinking water), EPA did not conduct

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[3] See https://www.epa.gov/sdwa (accessed December 8, 2025) for more information.
[4] See https://www.epa.gov/dwucmr/third-unregulated-contaminant-monitoring-rule (accessed December 8, 2025) for more information.

a quantitative assessment of exposure for drinking water. For more details, see *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q).

4.2.1.4 Land Pathway

The complete set of 1,3-butadiene monitoring results for groundwater stored in the WQP (NWQMC, 2022; U.S. EPA, 2022b) was retrieved in January 2024. An updated set was retrieved in July 2025. The WQP data indicated all groundwater samples reported 1,3-butadiene concentrations below the MDL. Based on the low volume of releases to land (see *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)), the low risk of failure of the predominant release scenario (see *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q)), the physical and chemical properties of 1,3-butadiene (see *Physical, Chemistry, Fate and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)) as well as monitoring data indicating 1,3-butadiene is not detected in groundwater (NWQMC, 2022; U.S. EPA, 2022b), EPA did not perform a quantitative analysis for the land pathway because exposure to the general population is not expected to occur. For more details, see *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q), *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae) and *Water Quality Portal (WQP) Monitoring Data 2004 to 2025 for 1,3-Butadiene* (U.S. EPA, 2025al).

4.2.2 Weight of Scientific Evidence Conclusions for Environmental Concentrations

Based on the physical and chemical properties of 1,3-butadiene (*i.e.*, high volatility, low solubility, and low sorption tendencies (U.S. EPA, 2025ae)), the low release volume to land and water (U.S. EPA, 2025r), and the minimal detection of 1,3-butadiene in surface and groundwater, EPA has robust confidence that (1) air is the major pathway of exposure for 1,3-butadiene, and (2) contributions to exposure from the land and water pathways will be infrequent and at low levels. As a result, air is the only pathway EPA assessed quantitatively.

For regions where monitoring data are available, EPA has robust confidence in the overall characterization of environmental media concentrations for 1,3-butadiene because it relies upon standard reporting databases with strictly regulated monitoring requirements, such as AMTIC, WQP, and UCMR, and extracted data from peer-reviewed literature that received medium- to high-quality ratings from EPA's systematic review process. In addition, states with a concentration of facilities releasing 1,3-butadiene are included in the monitoring databases. Due to the presence of 1,3-butadiene releasing facilities, these states would be expected to have the largest 1,3-butadiene releases. Therefore, EPA has robust confidence in the representativeness of the databases.

5 HUMAN HEALTH RISK ASSESSMENT

1,3-Butadiene – Human Health Risk Assessment (Section 5):
Key Points

EPA evaluated all reasonably available information to support human health risk characterization of 1,3-butadiene for workers, ONUs, consumers, bystanders, as well as the general population exposed to ambient air releases. These exposures are described in Section 5.1; human health hazards in Section 5.2; and human health risk characterization in Section 5.3.

Occupational Exposure Key Points

- 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.
- Due to a robust activity-specific dataset (that included personal protective equipment [PPE] information), EPA has high confidence that risk estimates derived from central tendency and high-end values are reflective of real-world workplace exposures.
- Inhalation exposures to 1,3-butadiene are highest in industrial settings for tasks such as repackaging and plastics and rubber polymerization.
- Uncertainty is introduced to the exposure assessment due to lack of directly applicable and quantified 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.

Consumer Exposure Key Points

- Based on product searches and systematic review data, EPA determined that 1,3-butadiene, a monomer incorporated into polymer-derived products such as synthetic rubbers and adhesives, are stable in consumer products and not expected to degrade and expose the consumer to the 1,3-butadiene monomer.
- EPA conducted a sensitivity analysis for exposure and risk estimates using the Consumer Exposure Model (CEM) and range of product weight fractions. EPA did not find risk to the consumer—even when exaggerated weight fractions were input into the model.

General Population Exposure Key Points

- EPA used HEM to model exposures to the general population from industrial releases to ambient air reported to TRI for 2016 to 2021 (Tier 2 evaluation). EPA further refined modeling for TRI facilities using corresponding NEI 2017 and 2020 releases (Tier 3 evaluation).
- Concentrations from industrial releases of 1,3-butadiene that can be attributed to COUs based on modeling at radial distances from releasing points range from 0.0 to 386.4 µg/m³ (based on NEI releases), with highest modeled concentrations associated with manufacturing and processing COUs/OESs.

Hazard Key Points

- The human equivalent concentration (HEC) used for risk estimation of intermediate and chronic exposures was 2.5 ppm (5.5 mg/m^3) and based on reduced fetal body weight in mice with a total uncertainty factor (UF) of 30.
- The chronic occupational unit risk (UR) to be used for subsequent risk estimation of cancer to workers was 0.00644 per ppm (2.91×10^{-6} per µg/m^3) based on leukemia and bladder cancer.
- Due to the mutagenic mode of action, the general population IUR is 0.0129 per ppm (5.83×10^{-6} per µg/m^3) based on incorporation of age-dependent adjustment factors (ADAFs) to account for exposed younger life stages.

1,3-Butadiene – Human Health Risk Assessment (Section 5):
Key Points Continued

Risk Assessment Key Points

- Occupational scenarios assessed using monitoring data
  - Risk was indicated at high-end for several OESs and similarly exposed groups (SEGs), including those associated with Manufacturing, Processing as a reactant, and Plastics and rubber compounding and converting.
  - Several OESs were found to have risk at both high-end and central tendency exposures. Among these OESs were Repackaging, Plastics and rubber polymerization, Recycling, and Disposal.
- Consumer scenarios
  - EPA did not find non-cancer risk to consumers from children's toys, even assuming exaggerated weight fractions; therefore, lifetime cancer risk is not expected to be relevant to this scenario.
- General population exposed to environmental releases
  - EPA used a three-tiered approach for assessing general population exposures and risks.
  - For tier I, EPA used the Integrated Indoor/Outdoor Air Calculator (IIOAC) to model industrial releases reported to TRI for the years 2016 through 2021.
  - Tier I-modeled concentrations and risk estimates with IIOAC and TRI facility releases resulted in cancer risk estimates that warranted refined analyses.
  - For tier II, EPA used the Human Exposure Model (HEM) for industrial releases reported to TRI for the years 2016 through 2021.
  - Tier II-modeled concentrations and risk estimates with HEM and TRI facilities releases resulted in cancer risk estimates that warranted refined analyses; aggregate non-cancer MOE exceeded a benchmark of 30.
  - For tier III, EPA used HEM for industrial releases reported to NEI for the years 2017 and 2020. Based on radial distance modeling results, and the 95th percentile modeled concentrations, cancer risk estimates were 6.2×10^{-4}, 9.8×10^{-5} and 2.1×10^{-5} at the 100, 100–1,000 m, and 1,000 m distances, respectively, based on NEI 2017 and 2020 reporting years, with manufacturing and processing COUs/OESs resulting in the highest risk estimates.
  - Based on census block results, maximum facility cancer risk estimates ranged from 3.1×10^{-11} to 3.4×10^{-5} with manufacturing and processing COUs/OESs resulting in the highest risk estimates.
  - Based on geospatial analysis, elevated cancer risk estimates are concentrated along the Gulf Coast region from Texas to Louisiana.

5.1 Summary of Human Exposures

For this fit-for-purpose, TSCA risk assessment, EPA targeted its review of environmental releases to point sources. Combustion sources related to facilities tied to COUs were evaluated for exposure assessment. Other sources of combustion, such as, mobile emissions, tobacco smoke, wood burning, and natural fires, were not independently evaluated in the exposure assessment. However, these sources were considered through inclusion and discussion of the EPA's Office of Air AirToxScreen assessment to provide additional context for other sources of 1,3-butadiene. The Agency focused its environmental release assessment on total facility emissions which can include emissions from both uses of 1,3-butadiene and combustion sources at the same facility or, potentially, only combustion sources from that facility.

5.1.1 Occupational Exposures

5.1.1.1 Summary of Occupational Exposure Assessment

EPA's general approach for estimating occupational exposures and the specific basis for each estimate is discussed in the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S.

EPA, 2025r). Table 5-1 summarizes the occupational inhalation exposure results for each OES. 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, which refers to data from the same chemical but used for a different yet similar activity or OES. Inhalation exposures to 1,3-butadiene are highest in the industrial settings of repackaging and plastics and rubber polymerization. Dermal exposure was not assessed for 1,3-butadiene due to the volatility and transport method of the chemical.

Exposures were not quantified for commercial use of fuels and related products. Occupational exposures from liquid petroleum gas connections, cylinder leaks, and incomplete combustion are expected to be minimal. Exposures were also not quantitatively assessed for the commercial COUs covered by the OESs Use of plastics and rubber products and Use of lubricants and greases. Reasonably available evidence suggests that 1,3-butadiene monomer does not exist at concentrations above 6.6 ppm in rubber products or above quantifiable levels in lubricants and greases. Most descriptions of 1,3-butadiene indicated in relevant SDSs or other product reports referred either to upstream steps or to reacted polymeric forms.

Table 5-1. Summary of Occupational Inhalation Exposure Results for 1,3-Butadiene by Occupational Exposure Scenarios

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or 12-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Manufacturing – 8-hour	Infrastructure/ distribution operations	250	250	5.5E−03	0.44	455	102	Dataset assessed using MLE	*Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) for manufacturing and processing facilities
	Infrastructure/ distribution operations – nonroutine	5	5	0.37	0.78	3	2	Substitution method used for non-detects	
	Instrument and Electrical	250	250	2.6E−04	0.10	313	29	Dataset assessed using MLE	
	Instrument and Electrical – Nonroutine	5	5	0.13	0.13	5	0	Substitution method used for non-detects	
	Instrument and Electrical – Turnaround	14	14	1.7E−02	0.14	4	2	Substitution method used for non-detects	
	Laboratory technician	250	250	6.8E−03	0.24	215	57	Dataset assessed using MLE	
	Machinery & specialists mechanical group	250	250	9.2E−04	0.25	222	44	Dataset assessed using MLE	
	Machinery & specialists mechanical group – turnaround	14	14	8.0E−03	1.2E−02	8	3	Substitution method used for non-detects	
	Maintenance	250	250	1.5E−02	0.70	354	109	Dataset assessed using MLE	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or }12\text{-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Manufacturing – 8-hour *(continued)*	Maintenance – nonroutine/other	5	5	0.34	0.62	2	1	Substitution method used for non-detects	*Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) for manufacturing and processing facilities *(continued)*
	Maintenance – turnaround	14	14	1.7E−02	5.1	33	15	Dataset assessed using MLE	
	Operations onsite	250	250	3.6E−04	0.13	1,952	229	Dataset assessed using MLE	
	Operations onsite – nonroutine/other	5	5	3.2E−02	0.13	38	2	Substitution method used for non-detects	
	Operations onsite – turnaround	14	14	2.0E−05	7.0E−02	1,633	116	Dataset assessed using MLE	
	Safety and Health Engineering	250	250	1.7E−02	0.49	21	6	Dataset assessed using MLE	
	ONU	250	250	5.8E−03	2.0E−02	39	9	Dataset assessed using MLE	
Manufacturing – 12-hour	Infrastructure/ distribution operations	167	167	5.5E−03	0.44	455	102	Dataset assessed using MLE	
	Infrastructure/ distribution operations – nonroutine	5	5	0.37	0.78	3	2	Substitution method used for non-detects	
	Instrument and Electrical	167	167	2.6E−04	0.10	313	29	Dataset assessed using MLE	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or 12-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Manufacturing – 12-hour *(continued)*	Instrument and Electrical – Nonroutine	5	5	0.13	0.13	5	0	Substitution method used for non-detects	*Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) for manufacturing and processing facilities *(continued)*
	Instrument and Electrical – Turnaround	14	14	1.7E−02	0.14	4	2	Substitution method used for non-detects	
	Laboratory technician	167	167	6.8E−03	0.24	215	57	Dataset assessed using MLE	
	Machinery & specialists mechanical group	167	167	9.2E−04	0.25	222	44	Dataset assessed using MLE	
	Machinery & specialists mechanical group – turnaround	14	14	8.0E−03	1.2E−02	8	3	Substitution method used for non-detects	
	Maintenance	167	167	1.5E−02	0.70	354	109	Dataset assessed using MLE	
	Maintenance – nonroutine/other	5	5	0.34	0.62	2	1	Substitution method used for non-detects	
	Maintenance – turnaround	14	14	1.7E−02	5.1	33	15	Dataset assessed using MLE	
	Operations onsite	167	167	3.6E−04	0.13	1,952	229	Dataset assessed using MLE	
	Operations onsite – nonroutine/other	5	5	3.2E−02	0.13	38	2	Substitution method used for non-detects	
	Operations onsite – turnaround	14	14	2.0E−05	7.0E−02	1,633	116	Dataset assessed using MLE	
	Safety and Health Engineering	167	167	1.7E−02	0.49	21	6	Dataset assessed using MLE	
	ONU	167	167	5.8E−03	2.0E−02	39	9	Dataset assessed using MLE	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or }12\text{-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Repackaging	Worker (full shift assumption)	250	250	0.45	22	158	87	Dataset assessed using MLE	Used task-length data from loading/ unloading during manufacturing and processing from *Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021)as analogous. ONU data not available; used the central tendency from worker estimates.
	ONU (full shift assumption)	250	250	0.45	0.45	0	0	N/A	
	Worker (task-length assumption)	250	250	2.6E−02	1.1	158	87	Dataset assessed using MLE	
	ONU (task-length assumption)	250	250	2.6E−02	2.6E−02	0	0	N/A	
Processing as a reactant – 8-hour	Infrastructure/ distribution operations	250	250	5.5E−03	0.44	455	102	Dataset assessed using MLE	*Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) data for manufacturing and processing facilities
	Infrastructure/ distribution operations – nonroutine	5	5	0.37	0.78	3	2	Substitution method used for non-detects	
	Instrument and electrical	250	250	2.6E−04	0.10	313	29	Dataset assessed using MLE	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or 12-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Processing as a reactant – 8-hour *(continued)*	Instrument and electrical – nonroutine	5	5	0.13	0.13	5	0	Substitution method used for non-detects	*Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) data for manufacturing and processing facilities *(continued)*
	Instrument and electrical – turnaround	14	14	1.7E−02	0.14	4	2	Substitution method used for non-detects	
	Laboratory technician	250	250	6.8E−03	0.24	215	57	Dataset assessed using MLE	
	Machinery & specialists mechanical group	250	250	9.2E−04	0.25	222	44	Dataset assessed using MLE	
	Machinery & specialists mechanical group – turnaround	14	14	8.0E−03	1.2E−02	8	3	Substitution method used for non-detects	
	Maintenance	250	250	1.5E−02	0.70	354	109	Dataset assessed using MLE	
	Maintenance – nonroutine/other	5	5	0.34	0.62	2	1	Substitution method used for non-detects	
	Maintenance – turnaround	14	14	1.7E−02	5.1	33	15	Dataset assessed using MLE	
	Operations onsite	250	250	3.6E−04	0.13	1952	229	Dataset assessed using MLE	
	Operations onsite – nonroutine/other	5	5	3.2E−02	0.13	38	2	Substitution method used for non-detects	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or 12-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Processing as a reactant – 8-hour *(continued)*	Operations onsite – turnaround	14	14	2.0E−05	7.0E−02	1633	116	Dataset assessed using MLE	*Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) data for manufacturing and processing facilities *(continued)*
	Safety and health engineering	250	250	1.7E−02	0.49	21	6	Dataset assessed using MLE	
	ONU	250	250	5.8E−03	2.0E−02	39	9	Dataset assessed using MLE	
Processing as a reactant – 12-hour	Infrastructure/ distribution operations	167	167	5.5E−03	0.44	455	102	Dataset assessed using MLE	
	Infrastructure/ distribution operations – nonroutine	5	5	0.37	0.78	3	2	Substitution method used for non-detects	
	Instrument and electrical	167	167	2.6E−04	0.10	313	29	Dataset assessed using MLE	
	Instrument and electrical – nonroutine	5	5	0.13	0.13	5	0	Substitution method used for non-detects	
	Instrument and electrical – turnaround	14	14	1.7E−02	0.14	4	2	Substitution method used for non-detects	
	Laboratory technician	167	167	6.8E−03	0.24	215	57	Dataset assessed using MLE	
	Machinery & specialists mechanical group	167	167	9.2E−04	0.25	222	44	Dataset assessed using MLE	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures C8- or 12-hour TWA				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Processing as a reactant – 12-hour *(continued)*	Machinery & specialists mechanical group – turnaround	14	14	8.0E−03	1.2E−02	8	3	Substitution method used for non-detects	*Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) data for manufacturing and processing facilities *(continued)*
	Maintenance	167	167	1.5E−02	0.70	354	109	Dataset assessed using MLE	
	Maintenance – nonroutine/other	5	5	0.34	0.62	2	1	Substitution method used for non-detects	
	Maintenance – turnaround	14	14	1.7E−02	5.1	33	15	Dataset assessed using MLE	
	Operations onsite	167	167	3.6E−04	0.13	1952	229	Dataset assessed using MLE	
	Operations onsite – nonroutine/other	5	5	3.2E−02	0.13	38	2	Substitution method used for non-detects	
	Operations onsite – turnaround	14	14	2.0E−05	7.0E−02	1633	116	Dataset assessed using MLE	
	Safety and health engineering	167	167	1.7E−02	0.49	21	6	Dataset assessed using MLE	
	ONU	167	167	5.8E−03	2.0E−02	39	9	Dataset assessed using MLE	
Processing – polymerization	Worker	250	250	0.40	17	1953	unknown	N/A	Based on summary statistics from 11 occupational monitoring studies: (Abdel-Rahman et al., 2001), (Albertini et al., 2003), (Albertini et al., 2007), (Ammenheuser et al., 2001), (Anttinen-Klemetti et al., 2006), (Carrieri et al., 2014), (Cheng et al., 2013), (Ma et al., 2000), (Van Sittert, 2000), (Ward et al., 2001), (Wickliffe et al., 2009)
	ONU	250	250	1.1E−02	9.9E−02	580	unknown	N/A	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or 12-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Processing – incorporation into formulation – 8-hour	Infrastructure/ distribution operations	250	250	5.5E−03	0.44	455	102	Dataset assessed using MLE	Used *Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) data for manufacturing and processing facilities as analogous
	Infrastructure/ distribution Operations – nonroutine	5	5	0.37	0.78	3	2	Substitution method used for non-detects	
	Instrument and electrical	250	250	2.6E−04	0.10	313	29	Dataset assessed using MLE	
	Instrument and electrical – nonroutine	5	5	0.13	0.13	5	0	Substitution method used for non-detects	
	Instrument and electrical – turnaround	14	14	1.7E−02	0.14	4	2	Substitution method used for non-detects	
	Laboratory technician	250	250	6.8E−03	0.24	215	57	Dataset assessed using MLE	
	Machinery & specialists mechanical group	250	250	9.2E−04	0.25	222	44	Dataset assessed using MLE	
	Machinery & specialists mechanical group – turnaround	14	14	8.0E−03	1.2E−02	8	3	Substitution method used for non-detects	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or 12-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Processing – incorporation into formulation – 8-hour *(continued)*	Maintenance	250	250	1.5E−02	0.70	354	109	Dataset assessed using MLE	Used *Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) data for manufacturing and processing facilities as analogous *(continued)*
	Maintenance – nonroutine/other	5	5	0.34	0.62	2	1	Substitution method used for non-detects	
	Maintenance – turnaround	14	14	1.7E−02	5.1	33	15	Dataset assessed using MLE	
	Operations onsite	250	250	3.6E−04	0.13	1952	229	Dataset assessed using MLE	
	Operations onsite – nonroutine/other	5	5	3.2E−02	0.13	38	2	Substitution method used for non-detects	
	Operations onsite – turnaround	14	14	2.0E−05	7.0E−02	1633	116	Dataset assessed using MLE	
	Safety and health engineering	250	250	1.7E−02	0.49	21	6	Dataset assessed using MLE	
	ONU	250	250	5.8E−03	2.0E−02	39	9	Dataset assessed using MLE	
Processing – incorporation into formulation – 12-hour	Infrastructure/ distribution operations	167	167	5.5E−03	0.44	455	102	Dataset assessed using MLE	
	Infrastructure/ distribution operations – nonroutine	5	5	0.37	0.78	3	2	Substitution method used for non-detects	
	Instrument and electrical	167	167	2.6E−04	0.10	313	29	Dataset assessed using MLE	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8-\text{ or }12\text{-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Processing – incorporation into formulation – 12-hour *(continued)*	Instrument and electrical – nonroutine	5	5	0.13	0.13	5	0	Substitution method used for non-detects	Used *Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) data for manufacturing and processing facilities as analogous *(continued)*
	Instrument and electrical – turnaround	14	14	1.7E−02	0.14	4	2	Substitution method used for non-detects	
	Laboratory technician	167	167	6.8E−03	0.24	215	57	Substitution method used for non-detects	
	Machinery & specialists mechanical group	167	167	9.2E−04	0.25	222	44	Dataset assessed using MLE	
	Machinery & specialists mechanical group – turnaround	14	14	8.0E−03	1.2E−02	8	3	Substitution method used for non-detects	
	Maintenance	167	167	1.5E−02	0.70	354	109	Dataset assessed using MLE	
	Maintenance – nonroutine/other	5	5	0.34	0.62	2	1	Substitution method used for non-detects	
	Maintenance – turnaround	14	14	1.7E−02	5.1	33	15	Dataset assessed using MLE	
	Operations onsite	167	167	3.6E−04	0.13	1,952	229	Dataset assessed using MLE	
	Operations onsite – nonroutine/other	5	5	3.2E−02	0.13	38	2	Substitution method used for non-detects	
	Operations onsite – turnaround	14	14	2.0E−05	7.0E−02	1,633	116	Dataset assessed using MLE	
	Safety and health engineering	167	167	1.7E−02	0.49	21	6	Dataset assessed using MLE	
	ONU	167	167	5.8E−03	2.0E−02	39	9	Dataset assessed using MLE	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or }12\text{-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Plastics and rubber compounding – 8-hour	Worker	250	250	6.9E−04	0.21	53	7	Dataset assessed using MLE	Based on OSHA's Chemical Exposure Health Database [c] and discrete data from 2 monitoring studies. (USTMA, 2020; Lee et al., 2012)
	ONU	250	250	6.9E−04	6.9E−04	0	0	N/A	
Plastics and rubber compounding – 12-hour	Worker	167	167	0.10	0.30	44	25	Dataset assessed using MLE	
	ONU	167	167	0.10	0.10	0	0	N/A	
Plastics and rubber converting – 8-hour	Worker	250	250	5.0E−04	0.18	50	6	Dataset assessed using MLE	
	ONU	250	250	5.0E−04	5.0E−04	0	0	N/A	
Plastics and rubber converting – 12-hour	Worker	167	167	0.10	0.30	44	25	Dataset assessed using MLE	
	ONU	167	167	0.10	0.10	0	0	N/A	
Use of laboratory chemicals – 8-hour	Laboratory technician	174	250	6.8E−03	0.24	215	57	Dataset assessed using MLE	Used full shift laboratory technician data during manufacturing and processing from *Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) as analogous.
	ONU	174	250	5.8E−03	2.0E−02	39	9	Dataset assessed using MLE	
Use of laboratory chemicals – 12-hour	Laboratory technician	167	167	6.8E−03	0.24	215	57	Dataset assessed using MLE	
	ONU	167	167	5.8E−03	2.0E−02	39	9	Dataset assessed using MLE	
Application of paints, coatings, adhesives, and sealants	Worker	250	250	4.5E−02	9.0E−02	43	0	Substitution method used for non-detects	Based on OSHA's CEHD [c] data. All values were below the limit of detection (LOD). Used LOD for the HE and LOD ÷ 2 for CT. ONU data not available; used the central tendency from worker estimates.
	ONU	250	250	4.5E−02	4.5E−02	0	0	N/A	

Occupational Exposure Scenario (OES)	Worker Description/ Job Group [a]	Exposure Frequency (day/yr)		Time Weighted Average (TWA) Exposures $C_{8\text{- or 12-hour TWA}}$				Method for Addressing Censored Data (Substitution or MLE [b])	Source(s)
		Central Tendency	High-End	Central Tendency (ppm)	High-End (ppm)	# Data Points	# Detected Data Points		
Recycling	Worker (full shift assumption)	250	250	0.23	1.3	10	1	Substitution method used for non-detects	Used task-length data from waste handling during manufacturing and processing from *Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021) as analogous. ONU data not available; used the central tendency from worker estimates
	ONU (full shift assumption)	250	250	0.23	0.23	0	0	N/A	
	Worker (task-length assumption)	250	250	1.7E−02	9.6E−02	10	1	Substitution method used for non-detects	
	ONU (task-length assumption)	250	250	1.7E−02	1.7E−02	0	0	N/A	
Waste handling, treatment, and disposal	Worker (full shift assumption)	250	250	0.23	1.3	10	1	Substitution method used for non-detects	Used task-length data from waste handling during manufacturing and processing from *Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021)as analogous. ONU data not available; used the central tendency from worker estimates
	ONU (full shift assumption)	250	250	0.23	0.23	0	0	N/A	
	Worker (task-length assumption)	250	250	1.7E−02	9.6E−02	10	1	Substitution method used for non-detects	
	ONU (task-length assumption)	250	250	1.7E−02	1.7E−02	0	0	N/A	

NIOSH = National Institute for Occupational Safety and Health; OSHA = Occupational Safety and Health Administration
[a] "Laboratory Technician – Non-routine" was a similarly exposed group (SEG) in the draft risk evaluation but is not present in the final because the source of the data clarified that the data on which that SEG was based was miscategorized.
[b] Maximum likelihood estimation (MLE). For more information see Section 5.3.2.
[c] OSHA CEHD can be accessed at https://www.osha.gov/opengov/health-samples (accessed December 8, 2025)

5.1.1.2 Weight of Scientific Evidence Conclusions for Occupational Exposure

EPA used 1,3-butadiene monitoring data that were either directly applicable to each scenario or from another comparable scenario as analogous. The use of monitoring data is preferable to other assessment approaches such as modeling or the use of occupational exposure limits (OELs). EPA used personal breathing zone (PBZ) air concentration data to assess inhalation exposures, with the data sources used in the majority of scenarios having a high data quality rating from the systematic review process.

There are two primary limitations to these occupational exposure estimates. The first limitation is the uncertainty of the representativeness of the data for scenarios to which monitoring data are used as analogous and for when task-length data were used to estimate a full shift exposure. Although use of analogous monitoring data is preferable to use of surrogate (data from another chemical) and modeling, the assumptions inherent in the use of analogous and task-length datasets introduce uncertainty into the relevant assessments. The second limitation is the large percentage of data used in the assessment that fell below their monitoring methods' LOD. Other limitations include the assumption of 250 exposure days per year in many cases when more scenario-specific information was not available. This exposure day estimate comes from the assumption that exposure days would be the same as facility operating days, but with a maximum of 250 days because EPA assumed that a single worker would not work more than 250 days per year. This assumption is applied to both central tendency and high-end exposures. However, it is uncertain whether this captures actual worker schedules and exposures.

In Table 5-2, EPA summarizes the weight of scientific evidence ratings for the occupational exposures for each OES. The Agency has the highest confidence (robust) in a number of similarly exposed groups (SEGs) within the OESs of Manufacturing and Processing as a reactant, both of which had large datasets of directly applicable monitoring data. Also receiving a robust confidence rating is Plastics and Rubber Polymerization, which used information from a variety of sources to estimate worker exposure. The lowest confidence is for Application of paints and coatings, Application of adhesives/sealants, Recycling, and Waste handling, treatment, and disposal (slight to moderate). For these scenarios, most or all monitored values in the assessment fell below the method LOD. Other OESs were moderate and several used analogous data from the Manufacturing/processing. For more detail, see *the Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r).

Table 5-2. Summary of the Weight of Scientific Evidence Ratings for Occupational Exposures for 1,3-Butadiene

Occupational Exposure Scenario (OES)	Inhalation Exposure												
	1,3-Butadiene Monitoring					Analogous Monitoring[a]					Modeling		Weight of Scientific Evidence Conclusion
	Worker	# Data Points [c]	ONU	# Data Points	Overall Quality Determin. [b]	Worker	# Data Points [c]	ONU	# Data Points [c]	Overall Quality Determin. [b]	Worker	ONU	
Manufacturing	✓	5,297	✓	39	H	✗	N/A	✗	N/A	N/A	✗	✗	Moderate to Robust (SEG-dependent)
Repackaging [f]	✗	N/A	✗	N/A	N/A	✓	158	✗	0	H	✗	✗	Moderate
Processing as a reactant	✓	5,297	✓	39	H	✗	N/A	✗	N/A	N/A	✗	✗	Moderate to Robust (SEG-dependent)
Processing – incorporation into formulation, mixture, or reaction product [d]	✗	N/A	✗	N/A	N/A	✓	5,297	✓	39	H	✗	✗	Moderate
Plastic and rubber polymerization	✓	1953	✓	580	M-H	✗	N/A	✗	N/A	N/A	✗	✗	Robust
Plastic and rubber compounding and converting	✓	53	✗	0	M-H	✗	N/A	✗	N/A	N/A	✗	✗	Moderate to Robust
Use of lab chemicals [e]	✗	N/A	✗	N/A	N/A	✓	215	✓	39	H	✗	✗	Moderate
Application of paints and coatings	✓	43	✗	0	M	✗	N/A	✗	N/A	N/A	✗	✗	Slight to Moderate
Application of adhesives and sealants	✓	43	✗	0	M	✗	N/A	✗	N/A	N/A	✗	✗	Slight to Moderate
Recycling [f]	✗	N/A	✗	N/A	N/A	✓	10	✗	0	H	✗	✗	Slight to Moderate
Waste handling, treatment, and disposal [f]	✗	N/A	✗	N/A	N/A	✓	10	✗	0	H	✗	✗	Slight to Moderate

Occupational Exposure Scenario (OES)	Inhalation Exposure												
	1,3-Butadiene Monitoring					Analogous Monitoring[a]					Modeling		Weight of Scientific Evidence Conclusion
	Worker	# Data Points [c]	ONU	# Data Points	Overall Quality Determin. [b]	Worker	# Data Points [c]	ONU	# Data Points [c]	Overall Quality Determin. [b]	Worker	ONU	

ONU = occupational non-user; SEG = similarly exposed group

[a] "Analogous data" refers to data from the same chemical and similar OESs.

[b] "H" indicates high score in systematic review and "M" indicates medium score in systematic review. EPA did not use sources that scored low in systematic review.

[c] Refer to Table 5-1 or more information about the datasets, including the number of non-detects.

[d] The dataset used in the Manufacturing and Processing as a reactant OESs was used as analogous for this OES

[e] The SEG of "Laboratory Technician" within the dataset used in the Manufacturing and Processing as a reactant OESs was used as analogous for this OES

[f] The data for these OES were from task-length sampling for relevant tasks (*e.g.*, unloading and loading, and waste handling) from 1,3-butadiene manufacturing and processing facilities.

5.1.2 Consumer Exposures

1,3-Butadiene is a component of plastics, resins, and synthetic rubber products, including children's toys. 1,3-Butadiene is used as a monomer in the production of the polymer-derived products, which include but are not limited to, ABS resins and SBR. These polymers are stable and not expected to degrade and expose the consumer to 1,3-butadiene monomer (Danish EPA, 2019). Systematic review identified that the highest residual level of 1,3-butadiene was reported in toys made from ABS at a weight fraction of 5.3×10^{-6} (0.00053%) (Abe et al., 2013). In addition, multiple studies have found minimal or no migration of 1,3-butadiene from toys to water, air, and food. (Omarova et al., 2021; Danish EPA, 2019; Startin and Gilbert, 1984). This indicates that 1,3-butadiene in consumer products, such as toys, is not anticipated to result in exposure through inhalation. Thus, EPA expects minimal release of 1,3-butadiene from consumer products, and therefore, minimal exposure to the consumer.

5.1.2.1 Summary of Consumer Exposure Assessment

EPA expects limited exposures to consumers from the 1,3-butadiene monomer used to produce polymer-derived products. However, in response to Science Advisory Committee on Chemicals (SACC) comments, EPA conducted a sensitivity analysis for the consumer exposure and risk assessment using CEM across a range of 1,3-butadiene weight fractions and surface areas in Section 5.3.3.

5.1.3 General Population Exposures to Environmental Releases

EPA expects the ambient air pathway to be the predominant human exposure pathway to 1,3-butadiene in the outdoor environment. 1,3-Butadiene is released from industrial facilities as uncontrolled fugitive releases (*e.g.*, process equipment leaks, process vents, building windows, building doors, roof vents) and stack releases that may be either uncontrolled (*e.g.*, direct releases out a stack) or controlled with a pollution control device (*e.g.*, baghouse, scrubber, thermal oxidizer). Once released to the ambient air, 1,3-butadiene may move off-site into the surrounding areas where the general population may be exposed through inhalation.

5.1.3.1 Summary of General Population Exposure Assessment

Based on the fate assessment for 1,3-butadiene, the monitored concentrations from the AMTIC database (U.S. EPA, 2022a), and the measured concentrations identified through systematic review (U.S. EPA, 2025q), EPA determined that 1,3-butadiene can be persistent in the ambient air and conducted a quantitative assessment for ambient air exposure to the general population. Ambient air concentrations of 1,3-butadiene based on facility releases from the TRI 2016 to 2021 reporting years were modeled using a tiered approach with the Integrated Indoor-Outdoor Air calculator (IIOAC) as a screening tool and followed by the Human Exposure Model (HEM) for refined modeling using the TRI (2016–2021 reporting years) and the NEI (2017 and 2020 reporting years) release data (the releases for 2022–2024 are comparable). EPA assumed that the general population is exposed to modeled ambient air concentrations 24 hours a day, 365 days a year over a lifetime. Therefore, exposure concentrations were equal to ambient air concentrations.

The 95th percentile modeled results from IIOAC for ambient concentrations near industrial facilities (within 100–1,000 m [0.062–0.62 miles]) releasing 1,3-butadiene to the ambient air ranged from 0.0 to 109.5 µg/m^3, with the highest concentrations modeled at 100 m from facility release points. Because IIOAC 95th and 50th percentile modeled concentrations resulted in corresponding risk estimates at or above 1 in a million, EPA proceeded with refined modeling using HEM. The 95th percentile-modeled results from HEM ranged from 0.0 to 91.2 µg/m^3 for populations living within 100 to 1,000 m from industrial facilities releasing 1,3-butadiene. For all distances modeled with HEM (10–50,000 m [0.006–31.06 miles]), the 95th percentile-modeled concentration ranged from 0.0 to 383.4 µg/m^3 with the highest concentrations modeled within the first 30 to 60 m away from facility release points. In addition, EPA conducted further refined modeling for the TRI facilities that had corresponding NEI 2017 and 2020 releases (*i.e.*, facilities that reported to both TRI and NEI databases). The 95th percentile-modeled ambient air concentrations from HEM across these NEI facility releases and all distances (10–50,000 m) ranged from 0.0 to 386.4 μg/m³, with the greatest concentrations modeled within the first 60 to 100 m from industrial facilities. This range is similar to the HEM 95th percentile results based on TRI releases. Appendix H.2 presents a ratio comparison between NEI and TRI cancer risk estimates and releases reported to both datasets for 51 facilities.

EPA used a tiered approach for evaluating general population exposures and risk estimates in Section 5.3.4. In addition, see the *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u) for the detailed assessment.

5.1.3.2 Weight of Scientific Evidence Conclusions for General Population Exposure

EPA has robust confidence in the overall characterization of exposures for this ambient air exposure assessment as it relies upon direct reported releases from databases that received a high-quality rating from the Agency's systematic review process and uses peer-reviewed models (IIOAC and HEM) to estimate ambient concentrations at distances from releasing facilities where individuals may reside or frequent throughout a lifetime. Use of an additional peer-reviewed model (AirToxScreen) from other EPA Program Offices (Office of Air and Radiation [OAR]) in conjunction with monitoring data (AMTIC) to further contextualize ambient air concentrations of 1,3-butadiene, provide added strength and confidence to the approaches and methods used in this ambient air exposure assessment. EPA acknowledges that the assumptions made for the general population being exposed to modeled ambient air concentrations 24 hours a day, 365 days a year, over a lifetime contributes uncertainty to the estimates.

The use of reported release data across multiple years of data provides a more comprehensive ambient air exposure assessment and ensure higher release years are not missed. Furthermore, use of actual industry reported releases reduces uncertainties around estimated releases and associated exposures for each OES evaluated. In addition, there is uncertainty in underlying parameters required for accurately estimating releases for cases where 1,3-butadiene is present in LPG, and only minimal monomer 1,3-butadiene is expected to be released from final use products. As a result, EPA did not quantify releases and resulting general population exposures from commercial use in fuels and related products or the Commercial COUs covered by the OES of Use of plastics and rubber products and Use of lubricants and greases. Risks from these COUs are expected to be low.

5.2 Summary of Human Health Hazard

In alignment with Section 4.2, EPA quantitatively evaluated hazards via the inhalation route; oral and dermal exposure to 1,3-butadiene is not expected. Inhalation hazards were assessed through systematic review of reasonably available evidence, which included human epidemiology, laboratory animal toxicology, and mechanistic data (including *in vitro* studies). EPA refined the systematic approach for 1,3-butadiene by reviewing previous authoritative reviews by federal agencies to better target the assessment. To this end, EPA utilized the IRIS *Health Assessment of 1,3-Butadiene* (2002a) and the Agency for Toxic Substances and Disease Registry (ATSDR) *Toxicological Profile for 1,3-Butadiene* (2012) to identify the primary hazards and key studies. Key studies from these assessments were supplemented with other literature that was "filtered" based on whether it was informative for dose-response analysis; however, all reasonably available information was considered for evaluating the weight of the scientific evidence.

1,3-Butadiene is readily absorbed through the lungs and distributed throughout the body with higher partitioning to adipose tissue. The primary metabolites are reactive mono- or di-epoxides, which can interact with biomolecules and induce toxicity. Qualitatively, metabolic pathways are identical between mice, rats, and humans. However, they are quantitatively different, with mice producing much greater levels of metabolites—especially di-epoxides. 1,3-Butadiene is primarily eliminated through exhalation, with additional excretion via urination, and individual urinary metabolites corresponding to specific epoxy metabolites and/or pathways. These metabolites are considered to be the source of toxicity, so species-specific toxicokinetic differences can influence relative species sensitivity.

EPA began the assessment by focusing on the endpoints and studies considered for deriving hazard values in (U.S. EPA, 2002a) and (ATSDR, 2012). Ovarian atrophy was the basis of the chronic reference concentration (RfC) in (U.S. EPA, 2002a) whereas (ATSDR, 2012) elected not to derive an inhalation minimum risk level (MRL) due to uncertainty in how to accurately extrapolate the mouse data to humans. Following a mode of action analysis, EPA concluded that ovarian atrophy observed in mice is not appropriate for quantitative use in human health risk assessment due to evidence suggesting greatly increased susceptibility in mice and difficulty in confidently quantifying cross-species differences. Instead, the Agency determined that three other critical hazard outcomes were appropriate for dose-response analysis. These non-cancer health outcomes were (1) maternal and related developmental toxicity, (2) male reproductive system and resulting developmental toxicity, and (3) hematological and immune effects.

1,3-Butadiene is a potent multi-organ carcinogen in laboratory animals, notably inducing lymphomas in mice and exhibiting greater carcinogenic potential in mice than rats. Epidemiological evidence consistently links occupational 1,3-butadiene exposure to increased mortality from lymphatic and hematopoietic cancers. EPA determined that 1,3-butadiene “is carcinogenic to humans,” based primarily on robust human, animal, and mechanistic evidence for lymphohematopoietic and bladder cancers—though varying evidence for other cancer types was also identified. Furthermore, the weight of scientific evidence supports a mutagenic mode of action for carcinogenicity.

Candidate endpoints for an acute point of departure (POD) from repeat-dose studies were considered but have substantial uncertainties as to whether they are relevant to acute exposures. They were also found to be less protective than the intermediate/chronic POD. Therefore, a hazard value was *not* derived for risk estimation of acute exposures because it is unlikely any adverse effects will result following a single exposure at concentrations relevant to human exposures. Additionally, the POD for repeated exposures is expected to be protective of any potential acute hazard. EPA performed dose-response analysis for multiple repeated-dose non-cancer endpoints under each hazard domain. Decreased fetal weight associated with other developmental toxicity outcomes was selected as the most sensitive and robust human-relevant endpoint for use in risk characterization of intermediate and chronic exposures. A human equivalent concentration (HEC) of 2.5 ppm (5.5 mg/m^3) with a total uncertainty factor (UF) of 30 was derived from benchmark dose modeling with a benchmark response of either 5 or 10 percent extra risk following dichotomization of male mouse fetal weight data. All other candidate PODs were higher but within 2- to 4-fold of this value.

EPA used an occupational epidemiological cohort with 50+ years of follow-up and subsequent exposure estimate updates to derive inhalation hazard values for leukemia and bladder cancer applicable to general population and occupational exposures. Due to an identified mutagenic mode of action for cancer, the Agency applied an age-dependent adjustment factor (ADAF) to the IUR for leukemia and bladder cancer for the general population; that is, risk scenarios where children or adolescents under 16 years old may be exposed. The IUR for general population risk estimation incorporating the ADAF is

0.00129 per ppm (5.83×10^{-6} per µg/m^3) while the chronic UR for occupational scenarios applied to adolescent and adult workers 16 years or older is 0.00644 per ppm (2.91×10^{-6} per µg/m^3).

EPA has robust overall confidence in the assessments and associated hazard values for maternal/developmental toxicity as well as leukemia and bladder cancer, both of which are used for risk estimation. These confidence ratings were based on the weight of scientific evidence considering evidence integration, selection of the critical endpoint and study, relevance to exposure scenarios, dose-response considerations, and incorporation of PESS.

Full details are provided in the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y).

5.2.1 Weight of Scientific Evidence Conclusions for Human Health Hazard

EPA evaluated the confidence for human health hazard conclusions based on the following factors: evidence integration conclusions, selection of the most critical endpoint and study, relevance to exposure scenarios, dose-response considerations, and incorporation of PESS. More details on how EPA evaluated these factors are provided in Section 6 of the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y).

Based on comparison of results from short-term studies with intermediate-duration studies, EPA has only slight confidence in any potential health effects following a single exposure at relevant human exposure levels. Intermediate PODs are expected to be protective of acute exposures. Therefore, EPA did not derive an acute POD.

EPA has robust overall confidence for the evidence integration, study/endpoint selection, exposure scenario applicability, dose-response, PESS sensitivity of the conclusions and PODs for maternal/developmental toxicity from gestational exposure, including the POD based on reduced fetal weight that are used for risk estimates. Multiple associated endpoints were observed at similar PODs and these effects were observed in both mice and rats, mitigating concerns about species-specificity of these effects.

There is robust human, animal, and mechanistic evidence associating leukemia and other lymphohematopoietic cancers, as well as bladder cancer, with 1,3-butadiene exposure. An IUR was derived for both leukemia and bladder cancer from studies incorporating years of updates to a large occupational cohort covering more than 60 years of follow up (Sathiakumar et al., 2021b; Sathiakumar et al., 2021a) and a novel lifetable analysis was performed to account for extra risk relative to background population rates. Both men and women were included in the analysis, and an ADAF was applied to incorporate elevated childhood susceptibility due to the mutagenic mode of action and in accordance with EPA guidance (U.S. EPA, 2005). Based on the above factors, the Agency has robust overall confidence in the hazard assessment and dose-response analysis for leukemia and bladder cancer. EPA combined the IUR from leukemia and bladder cancer to account for the total risk for multiple cancer types.

5.3 Human Health Risk Characterization

5.3.1 Risk Assessment Approach

EPA calculated non-cancer and cancer risk estimates for occupational and general population exposures following intermediate, chronic, and lifetime exposures. Risks were not estimated for acute exposures because sensitive organ-level endpoints are unlikely to result from a single exposure at concentrations relevant to human exposures (see Section 5.2 and the *Human Health Hazard Assessment for 1,3-*

Butadiene (U.S. EPA, 2025y)). Table 5-3 presents the scenarios, populations, assumptions, and hazard values used for risk estimation.

Table 5-3. Use Scenarios, Populations of Interest, and Toxicological Endpoints Used for Risk Estimation

Population of Interest and Exposure Scenario	**Workers and ONUs** Male and female adolescents and adults (16+ years old) and females of reproductive age directly working with 1,3-butadiene (in the case of workers) or indirectly exposed to 1,3-butadiene (in the case of ONUs) under light activity (breathing rate of 1.25 m^3/hour) (for further details see *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)) Exposure Durations • *Intermediate* – 8 hours per work day for up to 22 working days • *Chronic* – 8 hours per work day for up to 250 days per year for 31 or 40 working years Exposure Routes • Inhalation
	General Population Exposed to Environmental Releases EPA estimated risks to the general population of any life stage living near facilities releasing 1,3-butadiene into the environment via inhalation only following chronic or lifetime exposure. [a]
Health Effects, Hazard Values and Uncertainty Factors	**Non-Cancer POD for Intermediate and Chronic Risk Estimates [b]** HEC = 2.5 ppm (5,500 µg/m^3) based on decreased fetal weight • Adjusted for continuous exposure (24 hours/day, 7 days/week) *Benchmark MOE* = 30 (3× UF_A × 10× UF_H)
	Cancer Hazard Values for Chronic and Lifetime Cancer Risk Estimates Occupational UR = 0.00644 per ppm (2.91E−06 per µg/m^3) for leukemia and bladder • Adjusted for continuous (24 hours/day, 7 days/week) exposure and resting breathing rate (20 m^3/day); Used for estimating risks to workers ≥16 years old. General population IUR (ADAF-adjusted) = 0.0129 per ppm (5.83E−06 per µg/m^3) • Only for estimating risks to the general population where individuals <16 years old may be exposed.

ADAF = age-dependent adjustment factor; IUR = inhalation unit risk; UF_A = interspecies uncertainty factor; UF_H = intraspecies uncertainty factor

[a] EPA conservatively assumes that the general population may be exposed for the entirety of their lifetime. Therefore, general population chronic and lifetime exposures are equivalent.

[b] Both non-cancer and cancer hazard values are based on the most sensitive 95% confidence interval bound of their respective modeling (lower 95% level for non-cancer HEC from benchmark dose modeling, upper 95% β value for the cancer IUR).

5.3.1.1 Non-Cancer Risk Calculations

EPA used a margin of exposure (MOE) approach to estimate non-cancer risks. The MOE is the ratio of the non-cancer hazard value (or POD) divided by a human exposure dose. The chronic MOEs for non-cancer inhalation risks were calculated using Equation 5-1.

Equation 5-1. Margin of Exposure Calculation

$$MOE = \frac{Non - cancer\ Hazard\ Value\ (POD)}{Human\ Exposure}$$

Where:

MOE	= Margin of exposure for intermediate or chronic risk estimation (unitless)
Non-cancer Hazard Value (POD)	= Human equivalent concentration (HEC, $\mu g/m^3$)
Human Exposure	= Exposure estimate ($\mu g/m^3$)

MOE risk estimates are compared to benchmark MOEs. Benchmark MOEs are the product of all UFs for each non-cancer POD. The MOE estimate is interpreted as a human health risk of concern if the MOE estimate is less than the benchmark MOE (*i.e.*, the total UF). The larger the MOE, the more unlikely it is that a non-cancer adverse effect will occur. When determining whether a chemical substance presents unreasonable risk to human health or the environment, calculated risk estimates are not "bright-line" indicators of unreasonable risk, and EPA has the discretion to consider other risk-related factors in addition to risks identified in the risk characterization. Exposure-related considerations (*e.g.*, duration, magnitude, population exposed) can affect the Agency's characterization and of non-cancer risk.

Non-cancer hazard values were based on data from laboratory animal toxicology studies. The POD, reduced fetal body weight, is protective of other non-cancer endpoints—particularly germ cell mutations (model system: spermatogenic cells) and anemia that yielded similar POD values after 10 and 40 weeks of exposure, respectively.

5.3.1.2 Cancer Risk Calculations

Lifetime cancer risks for repeated exposures to a chemical were estimated using Equation 5-2.

Equation 5-2. Extra Lifetime Cancer Risk Calculation

$$Lifetime\ Cancer\ Risk = Human\ Exposure \times IUR/UR$$

Where:

Human Exposure	= Exposure estimate (lifetime average daily concentration [LADC] in ppm or $\mu g/m^3$; lifetime average daily dose [LADD] in mg/kg-day)
IUR/UR	= Inhalation or occupational unit risk; risk per unit of exposure (ppm or $\mu g/m^3$)

Consistent with NIOSH guidance, under TSCA EPA typically applies a 1×10^{-4} benchmark for occupational scenarios in industrial and commercial work environments subject to OSHA requirements. EPA typically considers the general population and consumer benchmark for cancer risk to be within the range of 1×10^{-4} to 1×10^{-6}. Again, it is important to note that these benchmarks are not bright-lines; EPA has discretion to find unreasonable risks based on other risk-related considerations based on the analysis. Exposure-related considerations (*e.g.*, duration, magnitude, population exposed) can affect EPA's characterization of the excess lifetime cancer risk.

5.3.1.3 Exposure Factors and Duration Adjustments

Risk calculations must compare exposure and hazard values with matching assumptions in order to allow direct comparison. When different assumptions are used for deriving the hazard and exposure values, separate adjustments must be made to the risk calculations. EPA derived a single set of hazard values to apply to all exposure scenarios; scenario-specific adjustments were therefore applied to exposure estimates.

In deriving HECs, EPA adjusted for dosimetry and continuous exposure duration in accordance with guidance documents (U.S. EPA, 2012a, 1994). The dosimetric impact of relative breathing rate was also considered when calculating risk estimates because increased breathing rate results in elevated internal dose/concentration. Therefore, occupational exposure was adjusted upward based on the relative ratio of occupational vs. general population breathing rates. The default breathing rate is 0.6125 m^3/hour (based on the average of mean long-term inhalation rates for adult males and females combined aged 21–81 years), while the occupational breathing rate is 1.25 m^3/hour (corresponding to light activity level) from (U.S. EPA, 2011). Occupational exposures were then adjusted as time-weighted averages (TWAs) over continuous exposure (30 days for intermediate, 365 days for chronic) for direct comparison to the HEC.

The general population IUR was adjusted for continuous ambient exposure by the default occupational ventilation rate and for the intermittent work week schedule (U.S. EPA, 1994). Because the IUR was derived from an occupational cohort study, the value was adjusted for continuous exposure by the general population (10 m^3/day and 240 days/year to 20 m^3/day and 365 days/year). The general population IUR was applied to general population risks because populations living near a release site may be exposed from birth. The chronic occupational unit risk is the cancer hazard value derived from the study cohort without ADAF applied because workers and ONUs are assumed to be at least 16 years old. As with non-cancer risks, occupational exposures were adjusted as TWAs over continuous exposure for direct comparison to the unit risk.

A summary of key adjustments to derived values across hazard, exposure, and risk calculations are summarized below. These adjustments were performed to ensure that assumptions for exposure duration, frequency, and breathing rate were matching/coordinated between the hazard and exposure values, when possible.

Exposure Frequency (Days/Year)

Hazard

- Non-cancer HECs were adjusted to continuous exposure based on 7 days/week.
- The cancer IUR lifetable assumed 240 working days per year for the exposed workers in the epidemiological cohort when adjusting to a continuous exposure basis of 365 days/year. This is practice is consistent with other contemporary EPA cancer hazard value derivations and risk evaluations (U.S. EPA, 2020d).

Exposure

- The occupational exposure assessment assumes a default of 250 working days/year, a consistent assumption among TSCA risk evaluations. This inconsistency between hazard and exposure in the exposure frequency assumption used to derive estimates results in a difference of 4 percent across exposure and risk estimates and does not impact any risk conclusions. Exposure/risk estimates are adjusted for scenarios that involve working less than 250 days/year.
- The general population exposure estimates are based on daily averages assuming exposure 365 days/year.

Exposure Duration (Hours/Day)

Hazard

- Non-cancer HECs were adjusted to continuous exposure based on 24 hours/day.
- The cancer IUR was adjusted based on a breathing rate (see more below) over 8 hours for workers to a breathing rate over 24 hours for the general population.

Exposure

- Occupational exposures were adjusted to a TWA of 24 hours/day to match hazard values.
- General population exposure estimates are based on daily averages assuming exposure 24 hours/day.

Exposure Length (Years/Lifetime)

Hazard

- Non-cancer intermediate HECs apply to less than 1 year of exposure and chronic HECs apply to any exposure covering at least 10 percent of lifetime (>7.8 years based on an assumed lifetime of 78 years).
- The adult-based unit risk for cancer was derived based on adjusting from the data on an occupational cohort (not exposed below 16 years of age) to a full lifetime of 78 years. The worker unit risk was derived assuming exposure from age 16 years through the end of a lifetime (62 years).

Exposure

- Occupational exposures cover a central tendency duration of 31 working years and a high-end duration of 40 years. For chronic non-cancer risks, the hazard values apply to the full duration of working years. For chronic cancer risks, LADC is adjusted based on the "lifetime exposure" duration used in the worker unit risk derivation (62 years). A typical lifetime of 78 years is not applied because the cancer unit risk assumed only a maximum of 62 years exposure.
- Non-cancer intermediate HECs apply to less than 1 year of exposure and chronic HECs apply to any exposure covering at least 10 percent of lifetime (>7.8 years based on an assumed lifetime of 78 years).

Breathing Rate

Hazard

- Non-cancer HECs (based on animal data) assume a default breathing rate of 14.7 m^3/day based on the Exposure Factors Handbook (U.S. EPA, 2011).
- The cancer IUR was adjusted from the assumed 10 m^3/day for workers (see below) in the occupational cohort, used to derive the IUR, to 20 m^3 over 24 hours (U.S. EPA, 1994) to apply to the general population. The 20 m^3 value is an older assumption that differs from the 14.7 m^3/day value from (U.S. EPA, 2011), but is the most chronologically accurate exposure factor based on the years the cohort was exposed.

Exposure

- Occupational exposures, for both workers and ONUs, were adjusted from TWA air concentrations by a breathing rate ratio of 2.0 to account for the difference between resting breathing rate of 14.7 m^3/day (0.6125/h) and 10 m^3/8-hour work day (1.25 m^3/h) (U.S. EPA, 2011, 1991).
- General population exposure estimates are based on ambient air concentrations without any adjustment for breathing rate (resting breathing rate of 14.7 m^3/day).

5.3.2 Risk Estimates for Workers

This section summarizes risk estimates for workers from inhalation exposures. Risks are calculated for all exposed workers based on the 1,3-butadiene-derived PODs described in Section 5.3.1. Occupational exposure values (OEVs) are discussed in Appendix F. This section provides discussion and characterization of risk estimates for workers, including females of reproductive age and ONUs, for the various OESs and COUs.

Occupational risk estimates utilized monitoring exposure measurements from 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 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a) and *Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2025aj). These data provided measurements at the level of individual worker populations (or SEGs). This granularity allowed EPA to differentiate even within OESs among different types of activities and frequencies.

Note that the majority of occupational exposure sampling data points used in these risk estimates were not quantified values but were identified as being below the LOD. For datasets that included exposure data that were reported as below the LOD, EPA estimated the exposure in one of three ways. In cases where the Agency had five or more detected samples in the dataset, the maximum likelihood estimation (MLE) method was chosen. MLE is considered a robust method of characterizing a dataset with a high number of non-detect samples; however, it should not be used in all cases because MLE requires some number of detected samples in order to estimate the distribution of the dataset. In cases where EPA had less than five detected samples, a substitution method was used to estimate the values of each non-detect sample in the dataset, as described in EPA's *Guidelines for Statistical Analysis of Occupational Exposure Data* (accessed December 5, 2025). In cases where EPA had a dataset with no data above the LOD, the data were still used for a screening level assessment where the LOD was used as the high-end, and one-half the LOD was used as the central tendency. When this screening level assessment was used, the MOEs were above the benchmark MOE of 30 for non-cancer, and below 1×10^{-4} added cancer risk, and so no further analysis was conducted. See Section 2.4.3.1 of the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r) for more information on each of these approaches.

As stated above, calculated risk estimates are not bright-line indicators of unreasonable risk relative to benchmarks, and EPA has the discretion to consider other risk-related factors in addition to risks identified in the risk characterization.

Sensitive, organ-level endpoints are unlikely to result from a single exposure at concentrations relevant to human exposures (Section 5.2 and the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y)). Therefore, low risks from all COUs are expected from acute occupational exposures. Similarly, because measurable dermal exposures are not expected due to the low boiling point, volatility, and transport method of 1,3-butadiene (see Section 5.1.1 and *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)), low risks from all COUs are expected from occupational dermal exposure. Additionally, inhalation exposures were not quantified for Commercial use of fuels and related products as well as Commercial COUs covered by the OESs of Use of plastics and rubber products and Use of lubricants and greases. Exposures are expected to be primarily minimal/negligible, and risk is expected to be low for these COUs. See Sections 3.11 and 3.14 in the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r) for more information.

Although both intermediate and chronic exposures were measured, only intermediate non-cancer risks are summarized below because they are protective of chronic exposures for the same health endpoint. All risk estimates are presented in Table 5-5. See Appendix F for derivation of the existing chemical occupational exposure value, which summarizes the OES and sensitive health endpoints into a single value, as well as the LOD for available governmental air sampling analytical methods. Note that in cases where there were no ONU exposure data available, it was assumed that ONU exposure is equal to the central tendency worker exposure. In such cases, ONUs may have only a single MOE.

Manufacturing, Processing as a Reactant, and Incorporation into Formulation, Mixture, or Reaction Product

The three OESs, Manufacturing, Processing as a reactant, and Incorporation into formulation, mixture, or reaction product, all used the same monitoring dataset for their inhalation exposure estimates and resulting risk estimates and so they are presented together. This applies to COUs covered under the Manufacturing, Processing as a reactant, and Incorporation into formulation, mixture, or reaction product OES (*e.g.*, Manufacturing: domestic manufacturing; Processing as reactant: intermediate, fuel, and recycling; Processing – incorporation into formulation, mixture, or reaction product: intermediate, monomers, other).

For these OESs of 1,3-butadiene, inhalation is expected to be the dominant route of exposure. MOEs for central tendency intermediate and chronic inhalation exposure ranged from 60 to 4.8×10^{6} for average adult workers and females of reproductive age (benchmark MOE = 30) for 8-hour shifts, and 40 to 3.2×10^{6} for 12-hour shifts. The high-end MOEs for the same populations and exposure scenarios ranged from 1.5 to 7,958 for 8-hour shifts and 1.0 to 5,323 for 12-hour shifts. For central tendency exposures extra cancer risk estimates range from 8.3×10^{-10} to 1.2×10^{-5} for 8-hour shifts, and 1.2×10^{-9} to 1.2×10^{-5} for 12-hour shifts (benchmark = 10^{-4}). The high-end, extra cancer risk estimates ranged from 6.4×10^{-7} to 6.9×10^{-4} for 8-hour shifts and from 9.6×10^{-7} to 6.7×10^{-4} for 12-hour shifts. Note that the values presented in this paragraph are with no use of PPE. Section 5.3.2.1 and Table 5-5 provide more information on PPE that could be used to reduce the calculated risk.

The high-end and central tendency worker inhalation exposure results for these OESs are based on over 5,500 full shift PBZ samples (between 2–1,952 samples per SEG) collected between 2010 and 2019 from 47 facilities that manufacture or process 1,3-butadiene (ToxStrategies, 2021). To determine central tendency and high-end values, EPA used 50th and 95th percentiles respectively for each SEG. Many of the data points were below the method's LOD, which adds uncertainty to the exposure and risk estimates, as discussed earlier in this section. Despite the high number of facilities, there is uncertainty as to (1) whether the measured concentrations and exposure frequencies from the single industry source accurately represent the entire industry, and (2) the true distribution of inhalation concentrations in this scenario. Also, the 47 facilities included in the source may manufacture or process 1,3-butadiene, and because this could not be differentiated, EPA assumed this dataset relevant to both scenarios. Since it is not known if these distinct uses of 1,3-butadiene would result in similar exposures, the blending of data from the manufacturing and processing of 1,3-butadiene could impact the results in a way that is not possible to know. EPA also assumed 250 exposure days per year for 8-hour TWAs and 167 exposure 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.

For manufacturing and processing, both the central and high-end exposure estimates are expected to be reflective of the range for worker inhalation exposures. Although the number of data points for many SEGs allows for a robust confidence rating, the SEGs of Infrastructure/distribution operations – nonroutine/other; Instrumental and electrical – nonroutine; Instrument and electrical – turnaround;

Machinery & specialists mechanical group – turnaround; Maintenance – nonroutine/other; and Operations onsite – nonroutine/other had few data points; therefore, there is less confidence in those estimates.

The available monitoring datasets did not include data specific to the Incorporation into formulation, mixture, or reaction product OES. In the absence of specific monitoring data, this dataset for the manufacturing and processing of 1,3-butadiene was used as analogous due to the similarity in expected activities. Because it is expected that a lower concentration of 1,3-butadiene would be involved in this scenario as opposed to manufacturing and processing, EPA believes this dataset to be a reasonable conservative estimate. The central tendency is likely more representative of worker exposure to this scenario rather than the high-end.

In the absence of PPE, SEGs with risk estimates below the benchmark MOE for non-cancer risks (intermediate and chronic), and/or had cancer risk estimates above 1×10^{-4} (1 in 10,000), are listed and described below:

- Infrastructure/ Distribution Operations (8- and 12-hour high-end, below benchmark MOE for intermediate and chronic, and had cancer risk estimates above 1×10^{-4}): 455 total samples, 29 samples above the high-end exposure value of 0.44 ppm.
- Infrastructure/ Distribution Operations – Nonroutine (8- and 12-hour high-end, below benchmark MOE for intermediate only): three total samples, one above the high-end exposure value of 0.78 ppm.
- Laboratory Technician (8- and 12- hour high-end, below benchmark MOE for intermediate and chronic, and had cancer risk estimates above 1×10^{-4}): 215 total samples, 16 samples above the high-end exposure value of 0.24 ppm.
- Machinery and Specialists (8- and 12-hour high-end, below benchmark MOE for intermediate and chronic, and had cancer risk estimates above 1×10^{-4}): 222 total samples, 12 samples above the high-end exposure value of 0.25 ppm.
- Maintenance (8- and 12-hour high-end, below benchmark MOE for intermediate and chronic, and had cancer risk estimates above 1×10^{-4}): 354 total samples, 2 above the high-end exposure value of 0.70 ppm.
- Maintenance – Nonroutine (12-hour high-end, below benchmark MOE for intermediate only): two total samples, one sample above the high-end exposure value of 0.62 ppm.
- Maintenance – Turnaround (8- and 12-hour high-end, below benchmark MOE for intermediate and chronic, and had cancer risk estimates above 1×10^{-4}): 33 total samples, 2 samples above the high-end exposure value of 5.1 ppm.
- Operations Onsite (8-hour and 12-hour high-end had cancer risk estimates above 1×10^{-4} , and 12-hour high-end below benchmark MOE for intermediate): 1,952 total samples, 360 above the high-end exposure value of 0.13 ppm.
- Safety, Health, and Engineering (8- and 12-hour high-end, below benchmark MOE for intermediate and chronic, and had cancer risk estimates above 1×10^{-4}): 21 total samples, 1 sample above the high-end exposure value of 0.49 ppm.

Repackaging

This section applies to COUs covered under the Repackaging OES (*i.e.*, Manufacturing – importing; Processing – repackaging – [wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing]).

For the Repackaging OES of 1,3-butadiene, inhalation is expected to be the dominant route of exposure. Because EPA had only task-based samples to estimate occupational exposure, two conditions were assessed. The first (full shift assumption) assumes that the estimated task-based exposure is occuring for an entire 8-hour shift. The second condition (task-length assumption) assumes that the estimated task takes place for the duration of the task and with no exposure for the remainder of the 8-hour shift. The values presented in the following paragraphs are with no use of PPE. Section 5.3.2.1 and Table 5-5 provide more information on PPE that could be used to reduce the calculated risk.

For the full shift assumption, the MOE for high-end intermediate inhalation exposure was 0.23 for average adult workers and females of reproductive age (benchmark MOE = 30), and for central tendency the MOE was 11 for 8-hour shifts. For high-end exposures the extra cancer risk estimate was 2.1×10^{-2} for 8-hour shifts (benchmark = 10^{-4}). The central tendency extra cancer risk estimate was 3.3×10^{-4} for 8-hour shifts.

For the task-length assumption, the MOE for high-end intermediate inhalation exposure was 4.4 for average adult workers and females of reproductive age (benchmark MOE = 30), and for central tendency the MOE was 196 for 8-hour shifts. For high-end exposures the extra cancer risk estimate was 1.1×10^{-3} for 8-hour shifts (benchmark = 10^{-4}). The central tendency extra cancer risk estimate was 1.9×10^{-5} for 8-hour shifts.

The inhalation exposure results for this OES are based on 158 task-length PBZ samples collected between 2010 and 2019 from 47 facilities that manufacture or process 1,3-butadiene (ToxStrategies, 2021). These task-length samples were labeled with the task "unloading and transferring 1,3-butadiene to and from storage containers to process vessels" and were chosen to be used as analogous to exposures that may occur at a repackaging facility where loading and unloading activities would be expected to regularly occur. To determine central tendency and high-end values, EPA used 50th and 95th percentiles respectively for each SEG. Although many of the samples in this dataset were below the method's LOD, more than half were above the detection limit, so EPA used MLE to determine the 50th and 95th percentiles.

An uncertainty in this estimation is the use of task-length exposure data from a manufacturing facility to estimate full shift exposure at a repackaging facility. However, EPA expects that the tasks conducted while collecting these samples would be similar to those tasks conducted regularly at a repackaging facility. Other uncertainties include the high number of samples below the LOD; there were 87 detects out of 158 samples. EPA used MLE to find the 50th and 95th percentiles in this case. EPA also assumed 250 exposure days per year based on the possibility of 1,3-butadiene exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures.

For this OES, both the central and high-end exposure estimates may be reflective of the range for possible worker inhalation exposures. The full shift assumption and task-length assumption together estimates the range of exposures that a worker may experience during this use of the chemical. Note that the task-length assumption may underestimate exposures, since it assumes the worker will have no additional exposure outside of the length of the task in a workplace known to have 1,3-butadiene. Also, the source indicates that the task is a routine occurrence, meaning that it generally occurs once per day at the manufacturing or processing site. It is likely that a repackaging facility will load and unload 1,3-butadiene more frequently than once daily.

In the absence of PPE, the risk estimates for this OES for workers and ONUs are below the benchmark MOE for intermediate and chronic non-cancer, and the cancer risk estimates were above 1×10^{-4} (1 in 10,000) for both central tendency and high-end exposures when considering the full shift assumption.

The full shift assumption had a total of 158 samples, with 6 samples above the high-end exposure of 22 ppm.

The risk estimates for this OES for workers are below the benchmark MOE for intermediate and chronic non-cancer, and the cancer risk estimates were above 1×10^{-4} (1 in 10,000) for the high-end when considering the task-length assumption. The task-length assumption had a total of 158 samples, with 6 samples above the high-end exposure of 1.14 ppm.

Plastic and Rubber Polymerization

This section applies to COUs covered under the Plastics and rubber polymerization OES (*i.e.*, Processing as a reactant: Monomer used in polymerization process).

For this OES of 1,3-butadiene, inhalation is expected to be the dominant route of exposure. The MOE for high-end intermediate was 0.30 for average adult workers and females of reproductive age (benchmark MOE = 30) for 8-hour shifts, and for central tendency the MOE was 13. For high-end exposures, the extra cancer risk estimate was 1.6×10^{-2} for 8-hour shifts and the central tendency extra cancer risk estimate was 2.9×10^{-4}. The values presented in this paragraph are with no use of PPE. Section 5.3.2.1 and Table 5-5 provide more information on PPE that could be used to reduce the calculated risk.

The central tendency and high-end worker inhalation exposure results for the OES are based on the means and max values from 11 sources dated from 2000 until 2014. A total of 1,953 samples for workers and 580 samples for ONUs contribute to the results. All but one study took place in the United States or other Organisation for Economic Co-operation and Development (OECD) country. The eleventh study took place in China but received a high rating in systematic review. To estimate central tendency, EPA calculated the overall mean of the 8-hour TWA exposures from the considered studies, weighing it to account for the number of samples that contributed to the mean of each study. To estimate high-end for workers, the Agency calculated the 95th percentile of the provided maximum measured values across the relevant monitoring studies. For ONUs, EPA used the maximum measured ONU value as a screening level conservative estimate.

The lack of discrete data points adds uncertainty to this assessment. The studies provided averages and number of samples among other summary information, but without the discrete data EPA does not know whether the handling of non-detects, among other data processing, is consistent across the studies, nor can EPA differentiate between the many different tasks that occur at polymerization facilities. While the number of sources is a strength of the estimate, some of the information from older sources, or sources from outside of the country, introduces uncertainty about the representativeness of the estimates to the United States in the present day. 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.

Both the central and high-end exposure estimates are expected to be reflective of the range for worker inhalation exposures. Although the high-end exposure estimate is conservative due to being the 95th percentile of the provided maximum measured value in the studies, because the highest value observed took place at a facility within the United States, it is reasonable to consider such exposure a possibility.

In the absence of PPE, the risk estimates for this OES for workers are below the benchmark MOE for intermediate and chronic non-cancer, and the cancer risk estimates were above 1×10^{-4} (1 in 10,000) for both central tendency and high-end exposures. EPA did not have a discrete dataset for this OES;

however, the high-end estimate was obtained by taking the 95th percentile of the reported maximum concentrations from multiple studies. Of the 41 maximum concentrations provided by the datasets, 2 samples were above the high-end value of 17 ppm.

Plastics and Rubber Compounding and Converting

This section applies to COUs covered under the Plastics and rubber compounding and converting OES (*i.e.*, Incorporation into formulation, mixture, or reaction product: plasticizer and monomer).

For this OES of 1,3-butadiene, inhalation is expected to be the dominant route of exposure. MOEs for high-end intermediate exposure ranged from 24 to 28 for average adult workers, including females of reproductive age (benchmark MOE = 30) for 8-hour shifts and was 11 for 12-hour shifts. The central tendency MOEs for the same populations and exposure scenarios ranged from 7,219 to 1.0×10^{4} for 8-hour shifts and was 33 for 12-hour shifts. For high-end exposures, the extra cancer risk estimates ranged from 1.7×10^{-4} to 2.0×10^{-4} for 8-hour shifts and 9.6×10^{-5} for 12-hour shifts (benchmark = 10^{-4}). The central tendency extra cancer risk estimates ranged from 3.7×10^{-7} to 5.1×10^{-7} for 8-hour shifts and 7.5×10^{-5} for 12-hour shifts. The values presented in this paragraph are with no use of PPE. Section 5.3.2.1 and Table 5-5 provide more information on PPE that could be used to reduce the calculated risk.

The high-end and central tendency worker inhalation exposure results for these OESs are based on 53 8-hour worker samples relevant to plastics and rubber compounding, 50 8-hour samples relevant to lastics and rubber converting, and 44 12-hour samples used for both. Note that the plastics and rubber compounding dataset uses the plastics and rubber converting dataset as analogous with an additional three data points relevant only to plastics and rubber compounding. These discrete samples came from three sources. To determine central tendency and high-end values, EPA used 50th and 95th percentiles respectively for each dataset. Many of the data points were below the method's LOD. In these cases, EPA used MLE to estimate the dataset's central tendency and high-end. The primary limitation is that the bulk of the data for plastic and rubber compounding is analogous from plastics and rubber converting. There is uncertainty in the representativeness of this data toward the true distribution of inhalation concentrations in these scenarios. Also, EPA 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.

Both the central tendency and high-end exposure estimates are expected to be reflective of the range for worker inhalation exposures.

In the absence of PPE, the risk estimates for plastics and rubber compounding and converting, for both 8- and 12-hour shifts for workers, are below the benchmark MOE for intermediate and chronic non-cancer and had cancer risk estimates above 1×10^{-4} (1 in 10,000) for high-end exposures. Central tendency risk estimates were above the benchmark MOEs for 8-hour shifts (1,000) and 12-hour shifts (33). For plastic compounding 8-hour, of a total of 53 samples, 5 exceeded the high-end exposure of 0.21 ppm. For plastic converting 8-hour, of a total of 50 samples, 6 exceeded the high-end exposure of 0.18. For plastic compounding and converting 12-hour, of a total of 44 samples, 2 exceeded the high-end exposure of 0.30 ppm.

Use of Laboratory Chemicals

This section applies to COUs covered under the Use of laboratory chemicals OES (*i.e.*, Commercial use: laboratory chemicals).

For this OES of 1,3-butadiene, inhalation is expected to be the dominant route of exposure. The MOE for high-end intermediate exposure was 21 for average adult workers and females of reproductive age (benchmark MOE = 30) for 8-hour shifts, and 14 for 12-hour shifts. For high-end exposures the extra cancer risk estimate was 2.3×10^{-4} for 8-hour and 12-hour shifts (benchmark = 10^{-4}). The central tendency MOE for the same populations and exposure scenarios was 735 for 8-hour shifts and 490 for 12-hour shifts. The central tendency extra cancer risk estimate was 5.0×10^{-6} for both 8- and 12-hour shifts. The values presented in this paragraph are with no use of PPE. Section 5.3.2.1 and Table 5-5 provide more information on PPE that could be used to reduce the calculated risk.

The high-end and central tendency worker inhalation exposure results for this OES are based on 215 full shift laboratory technician PBZ samples from the *Analysis of 1,3-Butadiene Industrial Hygiene Data* (ToxStrategies, 2021). The data from that report were collected between 2010 and 2019 from 47 facilities that manufacture or process 1,3-butadiene. This dataset for laboratory technicians in a manufacturing/processing facility is used as analogous for this OES that addresses exposures to laboratory workers in a commercial laboratory setting. To determine central tendency and high-end values, EPA used 50th and 95th percentiles. Of the 215 data points, only 57 were above the method LOD, so MLE was used to account for the non-detect samples.

The primary uncertainty in this dataset is the assumption that the exposures for a laboratory technician in a manufacturing and processing facility are comparable to the exposures for a laboratory technician in a commercial lab. Although many tasks are similar (analysis of samples), the lab technicians at manufacturing/processing sites perform some tasks that would not be expected in a commercial setting such as the collection of samples from the manufacturing or processing process. Despite this limitation, EPA did not find data more applicable to this scenario. The Agency 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.

Due to the use of analogous data in this case, the central tendency estimate is expected to be more representative of the range for laboratory workers in a commercial setting, as the high-end estimates may portray exposure to potentially high-exposure tasks that are exclusive to laboratory technicians in a manufacturing and process facility but would not occur in a commercial setting.

In the absence of PPE, the risk estimates for this OES for workers are below the benchmark MOE for intermediate and chronic non-cancer, and above the cancer risk benchmark (1 in 10,000) for high-end exposures. Of 215 total samples, 16 samples were above the high-end exposure value of 0.24 ppm. The central tendency risk estimates for the same populations and exposure scenarios were above the benchmark MOE for non-cancer and below the cancer benchmark.

Application of Paints and Coatings; Application of Adhesives and Sealants

The two OESs, Application of paints and coatings and Application of adhesives and sealants, used the same monitoring dataset for inhalation exposure estimates and resulting risk estimates and so they are presented together here. This section applies to COUs covered under the Application of adhesives and sealants and Application of paints and coatings OESs (*i.e.*, Industrial use: adhesives and sealants; Commercial use: paints and coatings, and adhesives and sealants).

For these OESs of 1,3-butadiene, inhalation is expected to be the dominant route of exposure. The MOE for high-end intermediate exposure was 55 for average adult workers and females of reproductive age (benchmark MOE = 30) for 8-hour shifts, and the central tendency MOE was 111. For high-end exposures the extra cancer risk estimate was 8.6×10^{-5} and central tendency extra cancer risk estimate was 3.3×10^{-5}. The values presented in this paragraph are with no use of PPE. Section 5.3.2.1 and Table 5-5 provide more information on PPE that could be used to reduce the calculated risk.

The high-end and central tendency worker inhalation exposure results for these OESs are based on 43 worker PBZ samples from 5 facilities between 2000 and 2016 obtained from OSHA CEHD. All samples tested were below the reportable 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 conservatively assessed the high-end inhalation exposures as the LOD and the central tendency as the LOD divided by 2. The primary limitation is that the data points were all below the LOD. There is uncertainty in the representativeness of this data toward the true distribution of inhalation concentrations in this scenario because OSHA CEHD does not provide worker activity descriptions. 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.

Both the central tendency and high-end exposure estimates are expected to be reflective of the range for worker inhalation exposures.

Recycling and Waste Handling Treatment, and Disposal

The two OESs, Recycling and Waste handling, treatment, and disposal, used the same monitoring dataset for inhalation exposure estimates and resulting risk estimates and so are presented together here. This applies to COUs covered under the Recycling and Waste handling, treatment, and disposal OESs (*i.e.*, disposal, disposal).

For these OESs of 1,3-butadiene, inhalation is expected to be the dominant route of exposure. Because EPA had only task-based samples to estimate occupational exposure, two conditions were assessed. The first (full shift assumption) assumes that the estimated task-based exposure is occurring for an entire 8-hour shift. The second condition (task-length assumption) assumes that the estimated task takes place for the duration of the task and with no exposure for the remainder of the 8-hour shift. The values presented in the following paragraphs are with no use of PPE. Section 5.3.2.1 and Table 5-5 provide more information on PPE that could be used to reduce the calculated risk.

For the full shift assumption, the MOE for high-end intermediate inhalation exposure was 3.9 for average adult workers, which includes females of reproductive age (benchmark MOE = 30) for 8-hour shifts, and the central tendency MOE was 22 for 8-hour shifts. For high-end exposures, the extra cancer risk estimate was 1.2×10^{-3} for 8-hour shifts (benchmark = 10^{-4}). The central tendency extra cancer risk estimate was 1.7×10^{-4} for 8-hour shifts.

The inhalation exposure results for this OES are based on 10 task-length PBZ samples collected between 2010 and 2019 from 1 or several of 47 possible facilities that manufacture or process 1,3-butadiene (ToxStrategies, 2021). These task-length samples were labeled with the task “handling, transporting and disposing of waste containing 1,3-butadiene” and so were chosen to be used as analogous to exposures that may occur at a recycling and waste handling facility where waste handling activities would be expected to regularly occur. To determine central tendency and high-end values, EPA used 50th and 95th percentiles respectively for each SEG. Because many of the data points were below the method’s LOD, EPA used a substitution method to estimate the value of the non-detects and then determined the 50th and 95th percentiles.

An uncertainty in this estimation is the use of task-length exposure data from a manufacturing facility instead of full shift exposure data from a recycling or waste handling facility. However, EPA expects that the tasks conducted while collecting these samples would be similar to those tasks conducted regularly at a recycling or waste handling facility. Other uncertainties include the high number of samples below the LOD; there was only 1 detect out of 10 samples. 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.

For these OESs, both the central and high-end exposure estimates may be reflective of the range for possible worker inhalation exposures. The full shift and task-length assumptions together estimates the range of exposures that a worker may experience during this use of the chemical. Note that the task-length assumption may underestimate exposures, since it assumes the worker will have no additional exposure outside of the length of the task in a workplace known to have 1,3-butadiene. Also, the source indicates that the task is a routine occurrence, meaning that it generally occurs once per day at the manufacturing or processing site. It is likely that a recycling or waste handling facility may perform recycling or waste handling tasks more frequently than once daily.

In the absence of PPE, the risk estimates for this OES for workers and ONUs are below the benchmark MOE for intermediate and chronic non-cancer, and cancer risk estimates above 1×10^{-4} (1 in 10,000) for both central tendency and high-end exposures when considering the full shift assumption. The risk calculations for this OES indicate risk for both central tendency and high-end when considering the full shift assumption. In this calculation, of the 10 total samples, 1 was above the high-end exposure of 1.3 ppm.

Summary

The risk estimates for a number of OESs and SEGs for workers are below the benchmark MOE for intermediate and chronic non-cancer, and the extra cancer risk estimate was above 1×10^{-4} (1 in 10,000) for high-end exposures. Several OESs are also below the benchmark MOE for intermediate and chronic non-cancer and had extra cancer risk estimates above 1×10^{-4} (1 in 10,000) at central tendency exposures. Among these OESs were Repackaging, Plastics and rubber polymerization, Recycling, and Disposal.

All risk estimates are presented below in Table 5-5. Colored shading and bolded values indicate scenarios where risk estimates were below the benchmark for non-cancer or were above 1×10^{-4} for cancer risk. The *Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2025af) contains all calculations, exposure values, and exposure factors, used for risk estimation.

5.3.2.1 Occupational Risk Estimates and Impacts of PPE

Submitted information from an industry consortium indicates that varying levels of respiratory PPE are implemented during high-intensity tasks. However, the available information does not indicate that respirators would be worn for the entirety of a shift; for example, one submitted industrial hygiene information packet (Docket: EPA-HQ-OPPT-2024-0425-0052) states the following:

> Consistent with AIHA Exposure Assessment Strategies guidance, full shift samples are likely to have been taken over time periods in which short term, or task level exposures might lead to exceedance of the permissible exposure limit (PEL). However, during such a task, workers would be wearing PPE, which may not be documented with the full shift sample, but rather with the task sample dataset.

While EPA does not have any information to suggest that respirators are worn for the entirety of the work day for any job group/SEG, the submitted industrial hygiene information does indicate what exposure controls, including PPE, apply to tasks that are undertaken by each job group. This information is summarized in Table 5-4. Widely varying levels of respirator protection are associated with each task (*e.g.*, unloading and unloading is associated with use of a supplied face respirator, full-face respirator, and half-face respirator). EPA assumes that the various respiratory protection options associated with tasks are based on an evaluation of exposure associated with the task at the various facilities. Therefore, a consistent level of respiratory protection cannot be assumed across a job group. However, wearing protection during high-intensity tasks may significantly reduce the overall full shift exposure if those tasks contribute a large percentage of the potential exposure during a shift. The tasks performed in any given day may vary widely, as would the associated exposure controls for the shift.

Occupational risk estimates are summarized in Table 5-5, including the estimated change in risk estimates assuming correct and continuous respirator usage at protection levels of Assigned Protection Factor (APF) 10 or 50. The summary table below focuses on these protection levels because they represent the most commonly used respiratory protection over a full shift associated with a half- or full-faced respirator. The adjusted MOE is presented for the lowest APF level to mitigate risks relative to benchmarks. When risks remain even at APF 50, a higher respiratory protection level (*e.g.*, 1,000, 10,000) is required, although these are highly unlikely to be used for a full shift duration. EPA has indicated alongside these modified risk estimates where the information in Table 5-4 indicates whether a respirator is always applied for these associated tasks. Risk estimates for all potential PPE options are presented in *Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2025af).

Notably, the submitted information only applies to the COUs of Manufacturing and Processing as a reactant, though EPA is assuming the same exposure controls for analogous exposure scenarios. There is additional uncertainty in the representativeness of this information because while the facilities contributing to this information are expected to represent 100 percent of U.S. manufacturers, they only represent 28 percent of the market operating under the Processing as a reactant COU (and not any other COUs except for use as analogous exposure estimates). The appropriateness of any protection factor that demonstrates exposures resulting in a worker MOE above the benchmark MOE may require additional consideration. The presented protection factors simply represent a value by which corresponding PPE may increase the estimated worker MOE above the benchmark MOE. The practicality and feasibility of implementing any PPE corresponding to a protection factor is part of a larger evaluation of effective occupational control strategies.

Table 5-4. Exposure Control Crosswalk for Job Group/SEGs and Tasks

Job Group/SEG	Tasks/Activities	Exposure Controls
Infrastructure/ Distribution/ Transportation Operations	**Unloading and Loading materials** to and from storage containers to process vessels	Vapor recovery systems Chemical protective gloves Suits and boots (to prevent dermal contact) Respirators: supp air, full-/half-face APR
	Opening process equipment (*e.g.*, storage vessels)	
	Sample collection	
	Cleaning filters	
	Handling hoses (*e.g.*, connections to truck tankers)	
	Loading/unloading tanks/trucks (*e.g.*, rail cars or cargo vessels and pumping material)	
	Handling utilities and waste streams	
	Handling of waste (transporting and disposing)	Chemical protective gloves Suits and boots (to prevent dermal contact) Respirators: full-/half-face APR
Instrument and Electrical	**Performing other work activities**	Chemical protective gloves Suits and boots (to prevent dermal contact) Respirators: supp air, full/half face APR, no respirator
	set up and maintenance of electrical equipment (analyzers and instruments across the facility)	
	opening the lines (like calibration and equipment maintenance)	
Laboratory Technician	**Collecting and analyzing samples**	Chemical protective gloves Suits and boots (to prevent dermal contact) Enclosed sample boxes Pressurized sample containers Laboratory ventilation cabinets Respirators: supp air, full-/half-face APR, no respirator
Machinery & Specialists Mechanical Group	**Performing other work activities**	Chemical protective gloves
	Opening process equipment prior to maintenance activities	Suits and boots (to prevent dermal contact) Respirators: supp air, full/half face APR, no respirator
Maintenance	**Cleaning and maintaining equipment**	Chemical protective gloves Suits and boots (to prevent dermal contact) Respirators: supp air, full/half face APR, no respirator
	Connecting and disconnecting lines	
	Draining, clearing and venting equipment	
Operations Onsite	**Cleaning and maintaining equipment**	Chemical protective gloves Suits and boots (to prevent dermal contact) Respirators: supp air, full/half face APR, no respirator
	Monitor chemical feeds, process temperatures, vessel pressure, etc.	

Job Group/SEG	Tasks/Activities	Exposure Controls
	Collecting and analyzing samples	Chemical protective gloves
	Drain/vent/clear process equipment and prepare it for maintenance	Suits and boots (to prevent dermal contact)
	Prepare process equipment for maintenance	Enclosed sample boxes Pressurized sample containers Laboratory ventilation cabinets Respirators: supp air, full/half face APR, no respirator
Safety, Health, and Environment (SHE)	**Performing other work activities**	Chemical protective gloves Suits and boots (to prevent dermal contact) Respirators: supp air, full/half face APR, no respirator
	Conduct exposure assessments of workers	
	monitor other workers or processes	
ONUs	**Performing other work activities**	Chemical protective gloves Suits and boots (to prevent dermal contact) Respirators: supp air, full/half face APR, no respirator
	Supervisory personnel associated with all of the worker job groups	

Source: *Analysis of 1,3-Butadiene Industrial Hygiene Data* (EPA-HQ-OPPT-2024-0425-0076).
Bold task indicates the parent task category to which exposure controls were designated. Rows underneath each bold task indicate associated activities; available information cannot differentiate exposure controls across activities.

Table 5-5. Occupational Risk Summary Table

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Manufacture/ Domestic manufacturing	Domestic manufacture	Manufacturing (8-hour shift)	Infrastructure/ Distribution Operations [a]	Inhalation 8-hour TWA	Central Tendency	906	970	4.1E−06	PPE not needed			Monitoring (MLE)
					High-End	**11**	**12**	**4.2E−04**	114 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)	Monitoring (MLE)
			Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 8-hour TWA	Central Tendency	60	725	5.4E−06	PPE not needed			Monitoring (sub)
					High-End	**28**	342	1.5E−05	281 (APF 10)	3,422 (APF 10)	1.5E−06 (APF 10)	Monitoring (sub)
			Instrument and Electrical [b]	Inhalation 8-hour TWA	Central Tendency	1.9E04	2.1E04	1.9E−07	PPE not needed			Monitoring (MLE)
					High-End	49	53	9.6E−05	PPE not needed			Monitoring (MLE)
			Instrument and Electrical – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	165	2,002	2.0E−06	PPE not needed			Monitoring (sub)
					High-End	165	2,002	2.5E−06	PPE not needed			Monitoring (sub)
			Instrument and Electrical – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	463	5,636	7.0E−07	PPE not needed			Monitoring (sub)
					High-End	57	689	7.4E−06	PPE not needed			Monitoring (sub)
			Laboratory Technician [b]	Inhalation 8-hour TWA	Central Tendency	735	787	5.0E−06	PPE not needed			Monitoring (MLE)
					High-End	**21**	**22**	**2.3E−04**	210 (APF 10)	225 (APF 10)	2.3E−05 (APF 10)	Monitoring (MLE)
			Machinery and Specialists [b]	Inhalation 8-hour TWA	Central Tendency	5,468	5,855	6.7E−07	PPE not needed			Monitoring (MLE)
					High-End	**20**	**22**	**2.4E−04**	202 (APF 10)	217 (APF 10)	2.4E−05 (APF 10)	Monitoring (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	**Intermediate Non-Cancer (Benchmark MOE = 30)**	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	
Manufacture/ Domestic manufacturing *(continued)*	Domestic manufacture *(continued)*	Manufacturing (8-hour shift) *(continued)*	Machinery and Specialists – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	984	1.2E04	3.3E−07	PPE not needed			Monitoring (sub)
					High-End	656	7,984	6.4E−07	PPE not needed			Monitoring (sub)
			Maintenance [b]	Inhalation 8-hour TWA	Central Tendency	333	357	1.1E−05	PPE not needed			Monitoring (MLE)
					High-End	**7.1**	**7.6**	**6.7E−04**	71 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)	Monitoring (MLE)
			Maintenance – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	65	787	5.0E−06	PPE not needed			Monitoring (sub)
					High-End	36	433	1.2E−05	PPE not needed			Monitoring (sub)
			Maintenance – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	466	5,667	7.0E−07	PPE not needed			Monitoring (MLE)
					High-End	**1.5**	**19**	**2.7E−04**	39 (APF 25)	188 (APF 10)	2.7E−05 (APF 10)	Monitoring (MLE)
			Operations Onsite [b]	Inhalation 8-hour TWA	Central Tendency	1.4E04	1.5E04	2.7E−07	PPE not needed			Monitoring (MLE)
					High-End	38	40	**1.3E−04**	376 (APF 10)	403 (APF 10)	1.3E−05 (APF 10)	Monitoring (MLE)
			Operations Onsite – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	689	8,384	4.7E−07	PPE not needed			Monitoring (sub)
					High-End	165	2,002	2.5E−06	PPE not needed			Monitoring (sub)
			Operations Onsite – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	3.9E05	4.8E06	8.3E−10	PPE not needed			Monitoring (MLE)
					High-End	113	1,377	3.7E−06	PPE not needed			Monitoring (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE: Intermediate Non-Cancer (Benchmark MOE = 30)	Risk Estimates for No PPE: Chronic Non-Cancer (Benchmark MOE = 30)	Risk Estimates for No PPE: Cancer (Benchmark = 1E−04)	PPE to Mitigate Risk (Max APF = 50): Intermediate Non-Cancer (Benchmark MOE = 30)	PPE to Mitigate Risk (Max APF = 50): Chronic Non-Cancer (Benchmark MOE = 30)	PPE to Mitigate Risk (Max APF = 50): Cancer (Benchmark = 1E−04)	Source of Data [e]
Manufacture/ Domestic manufacturing *(continued)*	Domestic manufacture *(continued)*	Manufacturing (8-hour shift) *(continued)*	Safety Health and Engineering [b]	Inhalation 8-hour TWA	Central Tendency	303	324	1.2E−05	PPE not needed			Monitoring (MLE)
					High-End	**10**	**11**	**4.6E−04**	103 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)	Monitoring (MLE)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	866	928	4.3E−06	–	–	–	Monitoring (MLE)
					High-End	245	263	1.9E−05	–	–	–	Monitoring (MLE)
		Manufacturing (12-hour shift)	Infrastructure/ Distribution Operations [a]	Inhalation 12-hour TWA	Central Tendency	604	968	4.1E−06	PPE not needed			Monitoring (MLE)
					High-End	**7.6**	**12**	**4.2E−04**	76 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)	Monitoring (MLE)
			Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 12-hour TWA	Central Tendency	40	483	8.2E−06	PPE not needed			Monitoring (sub)
					High-End	**19**	228	2.2E−05	188 (APF 10)	2,281 (APF 10)	2.2E−06 (APF 10)	Monitoring (sub)
			Instrument and Electrical [b]	Inhalation 12-hour TWA	Central Tendency	1.3E04	2.1E04	1.9E−07	PPE not needed			Monitoring (MLE)
					High-End	33	53	9.7E−05	PPE not needed			Monitoring (MLE)
			Instrument and Electrical – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	110	1,335	3.0E−06	PPE not needed			Monitoring (sub)
					High-End	110	1,335	3.8E−06	PPE not needed			Monitoring (sub)
			Instrument and Electrical – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	309	3,757	1.0E−06	PPE not needed			Monitoring (sub)
					High-End	38	460	1.1E−05	PPE not needed			Monitoring (sub)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Manufacture/ Domestic manufacturing *(continued)*	Domestic manufacture *(continued)*	Manufacturing (12-hour shift) *(continued)*	Laboratory Technician [b]	Inhalation 12-hour TWA	Central Tendency	490	785	5.0E−06	PPE not needed			Monitoring (MLE)
					High-End	**14**	**22**	**2.3E−04**	140 (APF 10)	224 (APF 10)	2.3E−05 (APF 10)	Monitoring (MLE)
			Machinery and Specialists [b]	Inhalation 12-hour TWA	Central Tendency	3,646	5,843	6.8E−07	PPE not needed			Monitoring (MLE)
					High-End	**13**	**22**	**2.4E−04**	135 (APF 10)	216 (APF 10)	2.4E−05 (APF 10)	Monitoring (MLE)
			Machinery and Specialists – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	656	7,984	4.9E−07	PPE not needed			Monitoring (sub)
					High-End	438	5,323	9.6E−07	PPE not needed			Monitoring (sub)
			Maintenance [b]	Inhalation 12-hour TWA	Central Tendency	222	356	1.1E−05	2,220 (APF 10)	3,559 (APF 10)	1.1E−06 (APF 10)	Monitoring (MLE)
					High-End	**4.8**	**7.6**	**6.7E−04**	48 (APF 10)	76 (APF 10)	6.7E−05(APF 10)	Monitoring (MLE)
			Maintenance – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	43	524	7.5E−06	PPE not needed			Monitoring (sub)
					High-End	**24**	289	1.8E−05	237 (APF 10)	2,889 (APF 10)	1.8E−06 (APF 10)	Monitoring (sub)
			Maintenance – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	311	3,778	1.0E−06	PPE not needed			Monitoring (MLE)
					High-End	**1.0**	**13**	**4.1E−04**	51 (APF 50)	125 (APF 10)	4.1E−05 (APF 10)	Monitoring (MLE)
			Operations Onsite [b]	Inhalation 12-hour TWA	Central Tendency	9,241	1.5E04	2.7E−07	PPE not needed			Monitoring (MLE)
					High-End	**25**	40	**1.3E−04**	251 (APF 10)	402 (APF 10)	1.3E−05 (APF 10)	Monitoring (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Manufacture/ Domestic manufacturing *(continued)*	Domestic manufacture *(continued)*	Manufacturing (12-hour shift) *(continued)*	Operations Onsite – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	459	5,589	7.1E−07	PPE not needed			Monitoring (sub)
					High-End	110	1,335	3.8E−06	PPE not needed			Monitoring (sub)
			Operations Onsite – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	2.6E05	3.2E06	1.2E−09	2.6E06 (APF 10)	3.2E07 (APF 10)	1.2E−10 (APF 10)	Monitoring (MLE)
					High-End	75	918	5.5E−06	755 (APF 10)	9,181 (APF 10)	5.5E−07 (APF 10)	Monitoring (MLE)
			Safety Health and Engineering [b]	Inhalation 12-hour TWA	Central Tendency	202	323	1.2E−05	2,018 (APF 10)	3,234 (APF 10)	1.2E−06 (APF 10)	Monitoring (MLE)
					High-End	**6.9**	**11**	**4.6E−04**	69 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)	Monitoring (MLE)
			ONU [c]	Inhalation 12-hour TWA	Central Tendency	578	926	4.3E−06	–	–	–	Monitoring (MLE)
					High-End	164	262	1.9E−05	–	–	–	Monitoring (MLE)
Manufacturing / Importing Processing/ Repackaging	Importing Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing	Repackaging (full shift assumption)	Worker [a]	Inhalation 8-hour TWA	Central Tendency	**11**	**12**	**3.3E−04**	111 (APF 10)	119 (APF 10)	3.3E−05 (APF 10)	Analogous (MLE)
					High-End	**0.23**	**0.24**	**2.1E−02**	**11** (APF 50)	**12** (APF 50)	**4.2E−04** (APF 50)	Analogous (MLE)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	**11**	**12**	**3.3E−04**	–	–	–	Analogous (MLE)
					High-End	**11**	**12**	**4.3E−04**	–	–	–	Analogous (MLE)
		Repackaging (task-length assumption)	Worker [a]	Inhalation 8-hour TWA	Central Tendency	196	210	1.9E−05	PPE not needed			Analogous (MLE)
					High-End	**4.4**	**4.7**	**1.1E−03**	44 (APF 10)	47 (APF 10)	4.3E−05 (APF 25)	Analogous (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	**Intermediate Non-Cancer (Benchmark MOE = 30)**	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	
Manufacturing / Importing Processing/ Repackaging *(continued)*	Importing Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing *(continued)*	Repackaging (task-length assumption) *(continued)*	ONU [c]	Inhalation 8-hour TWA	Central Tendency	196	210	1.9E−05	–	–	–	Analogous (MLE)
					High-End	196	210	2.4E−05	–	–	–	Analogous (MLE)
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling	Processing as a reactant (8-hour shift)	Infrastructure/ Distribution Operations [a]	Inhalation 8-hour TWA	Central Tendency	906	970	4.1E−06	PPE not needed			Monitoring (MLE)
					High-End	**11**	**12**	**4.2E−04**	114 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)	Monitoring (MLE)
			Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 8-hour TWA	Central Tendency	60	725	5.4E−06	PPE not needed			Monitoring (sub)
					High-End	**28**	342	1.5E−05	281 (APF 10)	3,422 (APF 10)	1.5E−06 (APF 10)	Monitoring (sub)
			Instrument and Electrical [b]	Inhalation 8-hour TWA	Central Tendency	1.9E04	2.1E04	1.9E−07	PPE not needed			Monitoring (MLE)
					High-End	49	53	9.6E−05	PPE not needed			Monitoring (MLE)
			Instrument and Electrical – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	165	2,002	2.0E−06	PPE not needed			Monitoring (sub)
					High-End	165	2,002	2.5E−06	PPE not needed			Monitoring (sub)
			Instrument and Electrical – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	463	5,636	7.0E−07	PPE not needed			Monitoring (sub)
					High-End	57	689	7.4E−06	PPE not needed			Monitoring (sub)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling *(continued)*	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling *(continued)*	Processing as a reactant (8-hour shift) *(continued)*	Laboratory Technician [b]	Inhalation 8-hour TWA	Central Tendency	735	787	5.0E−06	PPE not needed			Monitoring (MLE)
					High-End	**21**	**22**	**2.3E−04**	210 (APF 10)	225 (APF 10)	2.3E−05 (APF 10)	Monitoring (MLE)
			Machinery and Specialists [b]	Inhalation 8-hour TWA	Central Tendency	5,468	5,855	6.7E−07	PPE not needed			Monitoring (MLE)
					High-End	**20**	**22**	**2.4E−04**	202 (APF 10)	217 (APF 10)	2.4E−05 (APF 10)	Monitoring (MLE)
			Machinery and Specialists – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	984	1.2E04	3.3E−07	PPE not needed			Monitoring (sub)
					High-End	656	7,984	6.4E−07	PPE not needed			Monitoring (sub)
			Maintenance [b]	Inhalation 8-hour TWA	Central Tendency	333	357	1.1E−05	PPE not needed			Monitoring (MLE)
					High-End	**7.1**	**7.6**	**6.7E−04**	71 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)	Monitoring (MLE)
			Maintenance – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	65	787	5.0E−06	PPE not needed			Monitoring (sub)
					High-End	36	433	1.2E−05	PPE not needed			Monitoring (sub)
			Maintenance – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	466	5,667	7.0E−07	PPE not needed			Monitoring (MLE)
					High-End	**1.5**	**19**	**2.7E−04**	39 (APF 25)	188 (APF 10)	2.7E−05 (APF 10)	Monitoring (MLE)
			Operations Onsite [b]	Inhalation 8-hour TWA	Central Tendency	1.4E04	1.5E04	2.7E−07	PPE not needed			Monitoring (MLE)
					High-End	38	40	**1.3E−04**	376 (APF 10)	403 (APF 10)	1.3E−05 (APF 10)	Monitoring (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE: Intermediate Non-Cancer (Benchmark MOE = 30)	Risk Estimates for No PPE: Chronic Non-Cancer (Benchmark MOE = 30)	Risk Estimates for No PPE: Cancer (Bench-mark = 1E−04)	PPE to Mitigate Risk (Max APF = 50): Intermediate Non-Cancer (Benchmark MOE = 30)	PPE to Mitigate Risk (Max APF = 50): Chronic Non-Cancer (Benchmark MOE = 30)	PPE to Mitigate Risk (Max APF = 50): Cancer (Bench-mark = 1E−04)	Source of Data [e]
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling *(continued)*	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling *(continued)*	Processing as a reactant (8-hour shift) *(continued)*	Operations Onsite – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	689	8,384	4.7E−07	PPE not needed			Monitoring (sub)
					High-End	165	2,002	2.5E−06	PPE not needed			Monitoring (sub)
			Operations Onsite – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	3.9E05	4.8E06	8.3E−10	PPE not needed			Monitoring (MLE)
					High-End	113	1,377	3.7E−06	PPE not needed			Monitoring (MLE)
			Safety Health and Engineering [b]	Inhalation 8-hour TWA	Central Tendency	303	324	1.2E−05	PPE not needed			Monitoring (MLE)
					High-End	**10**	**11**	**4.6E−04**	103 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)	Monitoring (MLE)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	866	928	4.3E−06	PPE not needed			Monitoring (MLE)
					High-End	245	263	1.9E−05	PPE not needed			Monitoring (MLE)
		Processing as a reactant (12-hour shift)	Infrastructure/ Distribution Operations [a]	Inhalation 12-hour TWA	Central Tendency	604	968	4.1E−06	PPE not needed			Monitoring (MLE)
					High-End	**7.6**	**12**	**4.2E−04**	76 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)	Monitoring (MLE)
			Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 12-hour TWA	Central Tendency	40	483	8.2E−06	PPE not needed			Monitoring (sub)
					High-End	**19**	228	2.2E−05	188 (APF 10)	2,281 (APF 10)	2.2E−06 (APF 10)	Monitoring (sub)
			Instrument and Electrical [b]	Inhalation 12-hour TWA	Central Tendency	1.3E04	2.1E04	1.9E−07	PPE not needed			Monitoring (MLE)
					High-End	33	53	9.7E−05	PPE not needed			Monitoring (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	**Intermediate Non-Cancer (Benchmark MOE = 30)**	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling *(continued)*	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling *(continued)*	Processing as a reactant (12-hour shift) *(continued)*	Instrument and Electrical – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	110	1,335	3.0E−06	PPE not needed			Monitoring (sub)
					High-End	110	1,335	3.8E−06	PPE not needed			Monitoring (sub)
			Instrument and Electrical – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	309	3,757	1.0E−06	PPE not needed			Monitoring (sub)
					High-End	38	460	1.1E−05	PPE not needed			Monitoring (sub)
			Laboratory Technician [b]	Inhalation 12-hour TWA	Central Tendency	490	785	5.0E−06	PPE not needed			Monitoring (MLE)
					High-End	**14**	**22**	**2.3E−04**	140 (APF 10)	224 (APF 10)	2.3E−05 (APF 10)	Monitoring (MLE)
			Machinery and Specialists [b]	Inhalation 12-hour TWA	Central Tendency	3,646	5,843	6.8E−07	PPE not needed			Monitoring (MLE)
					High-End	**13**	**22**	**2.4E−04**	135 (APF 10)	216 (APF 10)	2.4E−05 (APF 10)	Monitoring (MLE)
			Machinery and Specialists – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	656	7,984	4.9E−07	PPE not needed			Monitoring (sub)
					High-End	438	5,323	9.6E−07	PPE not needed			Monitoring (sub)
			Maintenance [b]	Inhalation 12-hour TWA	Central Tendency	222	356	1.1E−05	PPE not needed			Monitoring (MLE)
					High-End	**4.8**	**7.6**	**6.7E−04**	48 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)	Monitoring (MLE)
			Maintenance – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	43	524	7.5E−06	PPE not needed			Monitoring (sub)
					High-End	**24**	289	1.8E−05	237 (APF 10)	2,889 (APF 10)	1.8E−06 (APF 10)	Monitoring (sub)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Processing/ Processing as a reactant Processing/ Use−non-incorporative activities Processing/ Recycling *(continued)*	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling *(continued)*	Processing as a reactant (12-hour shift) *(continued)*	Maintenance – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	311	3,778	1.0E−06	PPE not needed			Monitoring (MLE)
					High-End	**1.0**	**13**	**4.1E−04**	51 (APF 50)	125 (APF 10)	4.1E−05 (APF 10)	Monitoring (MLE)
			Operations Onsite [b]	Inhalation 12-hour TWA	Central Tendency	9,241	1.5E04	2.7E−07	PPE not needed			Monitoring (MLE)
					High-End	**25**	40	**1.3E−04**	251 (APF 10)	402 (APF 10)	1.3E−05 (APF 10)	Monitoring (MLE)
			Operations Onsite – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	459	5,589	7.1E−07	PPE not needed			Monitoring (sub)
					High-End	110	1,335	3.8E−06	PPE not needed			Monitoring (sub)
			Operations Onsite – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	2.6E05	3.2E06	1.2E−09	PPE not needed			Monitoring (MLE)
					High-End	75	918	5.5E−06	PPE not needed			Monitoring (MLE)
			Safety Health and Engineering [b]	Inhalation 12-hour TWA	Central Tendency	202	323	1.2E−05	PPE not needed			Monitoring (MLE)
					High-End	**6.9**	**11**	**4.6E−04**	69 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)	Monitoring (MLE)
			ONU [c]	Inhalation 12-hour TWA	Central Tendency	578	926	4.3E−06	–	–	–	Monitoring (MLE)
					High-End	164	262	1.9E−05	–	–	–	Monitoring (MLE)
Processing/ Processing as a reactant	Monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing)	Plastics and rubber polymerization	Worker [d]	Inhalation 8-hour TWA	Central Tendency	**13**	**14**	**2.9E−04**	127 (APF 10)	136 (APF 10)	2.9E−05 (APF 10)	Monitoring (summary)
					High-End	**0.30**	**0.32**	**1.6E−02**	**15** (APF 50)	**16** (APF 50)	**3.2E−04** (APF 50)	Monitoring (summary)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Processing/ Processing as a reactant *(continued)*	Monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing) *(continued)*	Plastics and rubber polymerization *(continued)*	ONU [c]	Inhalation 8-hour TWA	Central Tendency	438	469	8.4E−06	–	–	–	Monitoring (summary)
					High-End	51	54	9.4E−05	–	–	–	Monitoring (summary)
Processing/ Processing – incorporation into formulation, mixture, or reaction product	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities)	Processing – incorporation into formulation, mixture, or reaction product (8-hour shift)	Infrastructure/ Distribution Operations [a]	Inhalation 8-hour TWA	Central Tendency	906	970	4.1E−06	PPE not needed			Analogous (MLE)
					High-End	**11**	**12**	**4.2E−04**	114 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)	Analogous (MLE)
			Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 8-hour TWA	Central Tendency	60	725	5.4E−06	PPE not needed			Analogous (sub)
					High-End	**28**	342	1.5E−05	281 (APF 10)	3,422 (APF 10)	1.5E−06 (APF 10)	Analogous (sub)
			Instrument and Electrical [b]	Inhalation 8-hour TWA	Central Tendency	1.9E04	2.1E04	1.9E−07	PPE not needed			Analogous (MLE)
					High-End	49	53	9.6E−05	PPE not needed			Analogous (MLE)
			Instrument and Electrical – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	165	2,002	2.0E−06	PPE not needed			Analogous (sub)
					High-End	165	2,002	2.5E−06	PPE not needed			Analogous (sub)
			Instrument and Electrical – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	463	5,636	7.0E−07	PPE not needed			Analogous (sub)
					High-End	57	689	7.4E−06	PPE not needed			Analogous (sub)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	**Intermediate Non-Cancer (Benchmark MOE = 30)**	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	
Processing/ Processing – incorporation into formulation, mixture, or reaction product *(continued)*	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities) *(continued)*	Processing – incorporation into formulation, mixture, or reaction product (8-hour shift) *(continued)*	Laboratory Technician [b]	Inhalation 8-hour TWA	Central Tendency	735	787	5.0E−06	PPE not needed			Analogous (MLE)
					High-End	**21**	**22**	**2.3E−04**	210 (APF 10)	225 (APF 10)	2.3E−05 (APF 10)	Analogous (MLE)
			Machinery and Specialists [b]	Inhalation 8-hour TWA	Central Tendency	5,468	5855	6.7E−07	PPE not needed			Analogous (MLE)
					High-End	**20**	**22**	**2.4E−04**	202 (APF 10)	217 (APF 10)	2.4E−05 (APF 10)	Analogous (MLE)
			Machinery and Specialists – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	984	1.2E04	3.3E−07	PPE not needed			Analogous (sub)
					High-End	656	7,984	6.4E−07	PPE not needed			Analogous (sub)
			Maintenance [b]	Inhalation 8-hour TWA	Central Tendency	333	357	1.1E−05	PPE not needed			Analogous (MLE)
					High-End	**7.1**	**7.6**	**6.7E−04**	71 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)	Analogous (MLE)
			Maintenance – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	65	787	5.0E−06	PPE not needed			Analogous (sub)
					High-End	36	433	1.2E−05	PPE not needed			Analogous (sub)
			Maintenance – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	466	5,667	7.0E−07	PPE not needed			Analogous (MLE)
					High-End	**1.5**	**19**	**2.7E−04**	39 (APF 25)	188 (APF 10)	2.7E−05 (APF 10)	Analogous (MLE)
			Operations Onsite [b]	Inhalation 8-hour TWA	Central Tendency	1.4E04	1.5E04	2.7E−07	PPE not needed			Analogous (MLE)
					High-End	38	40	**1.3E−04**	376 (APF 10)	403 (APF 10)	1.3E−05 (APF 10)	Analogous (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Processing/ Processing – incorporation into formulation, mixture, or reaction product *(continued)*	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities) *(continued)*	Processing – incorporation into formulation, mixture, or reaction product (8-hour shift) *(continued)*	Operations Onsite – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	689	8,384	4.7E−07	PPE not needed			Analogous (sub)
					High-End	165	2,002	2.5E−06	PPE not needed			Analogous (sub)
			Operations Onsite – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	3.9E05	4.8E06	8.3E−10	PPE not needed			Analogous (MLE)
					High-End	113	1,377	3.7E−06	PPE not needed			Analogous (MLE)
			Safety Health and Engineering [b]	Inhalation 8-hour TWA	Central Tendency	303	324	1.2E−05	PPE not needed			Analogous (MLE)
					High-End	**10**	**11**	**4.6E−04**	103 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)	Analogous (MLE)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	866	928	4.3E−06	–	–	–	Analogous (MLE)
					High-End	245	263	1.9E−05	–	–	–	Analogous (MLE)
		Processing – incorporation into formulation, mixture, or reaction product (12-hour shift)	Infrastructure/ Distribution Operations [a]	Inhalation 12-hour TWA	Central Tendency	604	968	4.1E−06	PPE not needed			Analogous (MLE)
					High-End	**7.6**	**12**	**4.2E−04**	76 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)	Analogous (MLE)
			Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 12-hour TWA	Central Tendency	40	483	8.2E−06	PPE not needed			Analogous (sub)
					High-End	**19**	228	2.2E−05	188 (APF 10)	2,281 (APF 10)	2.2E−06 (APF 10)	Analogous (sub)
			Instrument and Electrical [b]	Inhalation 12-hour TWA	Central Tendency	1.3E04	2.1E04	1.9E−07	PPE not needed			Analogous (MLE)
					High-End	33	53	9.7E−05	PPE not needed			Analogous (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Processing/ Processing – incorporation into formulation, mixture, or reaction product *(continued)*	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities) *(continued)*	Processing – incorporation into formulation, mixture, or reaction product (12-hour shift) *(continued)*	Instrument and Electrical – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	110	1,335	3.0E−06	PPE not needed			Analogous (sub)
					High-End	110	1,335	3.8E−06	PPE not needed			Analogous (sub)
			Instrument and Electrical – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	309	3,757	1.0E−06	PPE not needed			Analogous (sub)
					High-End	38	460	1.1E−05	PPE not needed			Analogous (sub)
			Laboratory Technician [b]	Inhalation 12-hour TWA	Central Tendency	490	785	5.0E−06	PPE not needed			Analogous (MLE)
					High-End	**14**	**22**	**2.3E−04**	140 (APF 10)	224 (APF 10)	2.3E−05 (APF 10)	Analogous (MLE)
			Machinery and Specialists [b]	Inhalation 12-hour TWA	Central Tendency	3,646	5,843	6.8E−07	PPE not needed			Analogous (MLE)
					High-End	**13**	**22**	**2.4E−04**	135 (APF 10)	216 (APF 10)	2.4E−05 (APF 10)	Analogous (MLE)
			Machinery and Specialists – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	656	7,984	4.9E−07	PPE not needed			Analogous (sub)
					High-End	438	5,323	9.6E−07	PPE not needed			Analogous (sub)
			Maintenance [b]	Inhalation 12-hour TWA	Central Tendency	222	356	1.1E−05	PPE not needed			Analogous (MLE)
					High-End	**4.8**	**7.6**	**6.7E−04**	48 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)	Analogous (MLE)
			Maintenance – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	43	524	7.5E−06	PPE not needed			Analogous (sub)
					High-End	**24**	289	1.8E−05	237 (APF 10)	2,889 (APF 10)	1.8E−06 (APF 10)	Analogous (sub)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Processing/ Processing – incorporation into formulation, mixture, or reaction product *(continued)*	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities) *(continued)*	Processing – incorporation into formulation, mixture, or reaction product (12-hour shift) *(continued)*	Maintenance – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	311	3,778	1.0E−06	PPE not needed			Analogous (MLE)
					High-End	**1.0**	**13**	**4.1E−04**	51 (APF 50)	125 (APF 10)	4.1E−05 (APF 10)	Analogous (MLE)
			Operations Onsite [b]	Inhalation 12-hour TWA	Central Tendency	9,241	1.5E04	2.7E−07	PPE not needed			Analogous (MLE)
					High-End	**25**	40	**1.3E−04**	251 (APF 10)	402 (APF 10)	1.3E−05 (APF 10)	Analogous (MLE)
			Operations Onsite – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	459	5,589	7.1E−07	PPE not needed			Analogous (sub)
					High-End	110	1,335	3.8E−06	PPE not needed			Analogous (sub)
			Operations Onsite – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	2.6E05	3.2E06	1.2E−09	PPE not needed			Analogous (MLE)
					High-End	75	918	5.5E−06	PPE not needed			Analogous (MLE)
			Safety Health and Engineering [b]	Inhalation 12-hour TWA	Central Tendency	202	323	1.2E−05	PPE not needed			Analogous (MLE)
					High-End	**6.9**	**11**	**4.6E−04**	69 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)	Analogous (MLE)
			ONU [c]	Inhalation 12-hour TWA	Central Tendency	578	926	4.3E−06	–	–	–	Analogous (MLE)
					High-End	164	262	1.9E−05	–	–	–	Analogous (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Processing/ Processing – incorporation into formulation, mixture, or reaction product Processing/ Processing – incorporation into article	Plasticizer (asphalt paving, roofing, and coating materials manufacturing) Monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing) Monomer (rubber product manufacturing)	Plastics and rubber compounding	Worker [d]	Inhalation 8-hour TWA	Central Tendency	7,219	7,729	5.1E−07	PPE not needed			Monitoring (MLE)
					High-End	**24**	**26**	**2.0E−04**	243 (APF 10)	260 (APF 10)	2.0E−05 (APF 10)	Monitoring (MLE)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	7,219	7,729	5.1E−07	–	–	–	Monitoring (MLE)
					High-End	7,219	7,729	6.6E−07	–	–	–	Monitoring (MLE)
			Worker [d]	Inhalation 12-hour TWA	Central Tendency	33	53	7.5E−05	PPE not needed			Monitoring (MLE)
					High-End	**11**	**18**	**2.9E−04**	110 (APF 10)	177 (APF 10)	2.9E−05 (APF 10)	Monitoring (MLE)
			ONU [c]	Inhalation 12-hour TWA	Central Tendency	33	53	7.5E−05	–	–	–	Monitoring (MLE)
					High-End	33	53	9.6E−05	–	–	–	Monitoring (MLE)
		Plastics and rubber converting	Worker [d]	Inhalation 8-hour TWA	Central Tendency	1.0E04	1.1E04	3.7E−07	PPE not needed			Monitoring (MLE)
					High-End	**28**	**30**	**1.7E−04**	279 (APF 10)	299 (APF 10)	1.7E−05 (APF 10)	Monitoring (MLE)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	1.0E04	1.1E04	3.7E−07	–	–	–	Monitoring (MLE)
					High-End	1.0E04	1.1E04	4.7E−07	–	–	–	Monitoring (MLE)
			Worker [d]	Inhalation 12-hour TWA	Central Tendency	33	53	7.5E−05	PPE not needed			Monitoring (MLE)
					High-End	**11**	**18**	**2.9E−04**	110 (APF 10)	177 (APF 10)	2.9E−05 (APF 10)	Monitoring (MLE)
			ONU [c]	Inhalation 12-hour TWA	Central Tendency	33	53	7.5E−05	–	–	–	Monitoring (MLE)
					High-End	33	53	9.6E−05	–	–	–	Monitoring (MLE)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	
Commercial Use/ Other use	Laboratory chemicals	Use of laboratory chemicals	Laboratory Technician [b]	Inhalation 8-hour TWA	Central Tendency	735	787	5.0E−06	PPE not needed			Analogous (MLE)
					High-End	**21**	**22**	**2.3E−04**	210 (APF 10)	225 (APF 10)	2.3E−05 (APF 10)	Analogous (MLE)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	866	928	4.3E−06	–	–	–	Analogous (MLE)
					High-End	245	263	1.9E−05	–	–	–	Analogous (MLE)
			Laboratory Technician [b]	Inhalation 12-hour TWA	Central Tendency	490	785	5.0E−06	PPE not needed			Analogous (MLE)
					High-End	**14**	**22**	**2.3E−04**	140 (APF 10)	224 (APF 10)	2.3E−05 (APF 10)	Analogous (MLE)
			ONU [c]	Inhalation 12-hour TWA	Central Tendency	578	926	4.3E−06	–	–	–	Analogous (MLE)
					High-End	164	262	1.9E−05	–	–	–	Analogous (MLE)
Industrial Use / Adhesives and sealants Commercial Use / Paints and coatings Commercial Use / Adhesives and sealants	Adhesives and sealants, including epoxy resins Paints and coatings, including aerosol spray paint Adhesives and sealants, including epoxy resins	Paints, coatings, adhesives, and sealants	Worker [d]	Inhalation 8-hour TWA	Central Tendency	111	119	3.3E−05	PPE not needed			Monitoring (sub)
					High-End	55	59	8.6E−05	PPE not needed			Monitoring (sub)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	111	119	3.3E−05	–	–	–	Monitoring (sub)
					High-End	111	119	4.3E−05	–	–	–	Monitoring (sub)

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE: Intermediate Non-Cancer (Benchmark MOE = 30)	Risk Estimates for No PPE: Chronic Non-Cancer (Benchmark MOE = 30)	Risk Estimates for No PPE: Cancer (Bench-mark = 1E−04)	PPE to Mitigate Risk (Max APF = 50): Intermediate Non-Cancer (Benchmark MOE = 30)	PPE to Mitigate Risk (Max APF = 50): Chronic Non-Cancer (Benchmark MOE = 30)	PPE to Mitigate Risk (Max APF = 50): Cancer (Bench-mark = 1E−04)	Source of Data [e]
Disposal	Disposal	Recycling (full shift assumption)	Worker [a]	Inhalation 8-hour TWA	Central Tendency	**22**	**23**	**1.7E−04**	218 (APF 10)	233 (APF 10)	1.7E−05 (APF 10)	Analogous (sub)
					High-End	**3.9**	**4.1**	**1.2E−03**	39 (APF 10)	41 (APF 10)	4.9E−05 (APF 25)	Analogous (sub)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	**22**	**23**	**1.7E−04**	–	–	–	Analogous (sub)
					High-End	**22**	**23**	**2.2E−04**	–	–	–	Analogous (sub)
		Recycling (task-length assumption)	Worker [a]	Inhalation 8-hour TWA	Central Tendency	295	316	1.2E−05	2,955 (APF 10)	3,163 (APF 10)	1.2E−06 (APF 10)	Analogous (sub)
					High-End	52	56	9.1E−05	520 (APF 10)	557 (APF 10)	9.1E−06 (APF 10)	Analogous (sub)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	295	316	1.2E−05	–	–	–	Analogous (sub)
					High-End	295	316	1.6E−05	–	–	–	Analogous (sub)
		Waste handling, treatment, and disposal (full shift assumption)	Worker [a]	Inhalation 8-hour TWA	Central Tendency	**22**	**23**	**1.7E−04**	218 (APF 10)	233 (APF 10)	1.7E−05 (APF 10)	Analogous (sub)
					High-End	**3.9**	**4.1**	**1.2E−03**	39 (APF 10)	41 (APF 10)	4.9E−05 (APF 25)	Analogous (sub)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	**22**	**23**	**1.7E−04**	–	–	–	Analogous (sub)
					High-End	**22**	**23**	**2.2E−04**	–	–	–	Analogous (sub)
		Waste handling, treatment, and disposal (task-length assumption)	Worker [a]	Inhalation 8-hour TWA	Central Tendency	295	316	1.2E−05	2,955 (APF 10)	3,163 (APF 10)	1.2E−06 (APF 10)	Analogous (sub)
					High-End	52	56	9.1E−05	520 (APF 10)	557 (APF 10)	9.1E−06 (APF 10)	Analogous (sub)
			ONU [c]	Inhalation 8-hour TWA	Central Tendency	295	316	1.2E−05	–	–	–	Analogous (sub)
					High-End	295	316	1.6E−05	–	–	–	Analogous (sub)

Note: **bold** and gray-shaded text indicates that an MOE is below the MOE benchmark value of 30 or above a cancer risk of 1×10^{-4}.

APF = Assigned Protection Factor; margin of exposure; OES = occupational exposure scenario; PPE = personal protection equipment; SEG = similarly exposed group; TWA = time-weighted average

[a] According to Table 5-4, there is evidence that specific tasks associated with this job group always involve wearing of respirators for some facilities and COUs. However, a consistent level of respiratory protection cannot be assumed across a job group, and EPA does not have information to suggest that respirators are worn for the entirety of the work day for any job group/SEG.

Life Cycle Stage/ Category(ies)	Subcategory	OES	Job Group/ SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50)			Source of Data [e]
						Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	

[b] According to Table 5-4, there is evidence that specific tasks associated with this job group sometimes involve wearing of respirators. However, a consistent level of respiratory protection cannot be assumed across a job group, and EPA does not have information to suggest that respirators are worn for the entirety of the work day for any job group/SEG.
[c] Respirator use is not expected for ONUs.
[d] There is insufficient information to determine respirator use for workers in this OES.
[e] Data Sources are described briefly below. See Table 5-1 for more details on the data sources for the assessment of each OES.
Monitoring (MLE) = Directly applicable discrete monitoring data were used in the assessment, along with MLE to account for the non-detects in the dataset
Monitoring (sub) = Directly applicable discrete monitoring data were used in the assessment, with a substitution method used to account for the non-detects in the dataset
Monitoring (summary) = Summary statistics from multiple monitoring studies were used in the assessment
Analogous (MLE) = Discrete monitoring data from a similar activity was used in the assessment, along with MLE to account for the non-detects in the dataset
Analogous (sub) = Discrete monitoring data from a similar activity was used in the assessment, with a substitution method used to account for the non-detects in the dataset

5.3.3 Risk Estimates for Consumers

EPA has qualitatively evaluated the consumer COUs by assessing the possibility of 1,3-butadiene monomer exposure from polymer consumer use in Section 5.1.2 and concluded limited potential for exposure. However, in response to SACC recommendations for a tier I/screening level analysis for consumer risk estimates, the Agency conducted a sensitivity analysis for the consumer exposure and risk assessment using the CEM Version 3.2. The CEM estimates human inhalation, ingestion, and dermal acute and chronic exposure to chemicals through indoor air concentrations, indoor dust concentrations for a wide variety of consumer products, articles, and materials. For more details on CEM, see the user guide (U.S. EPA, 2023).

To determine 1,3-butadiene concentrations that present risk in toys, EPA conducted a sensitivity analysis for the consumer exposure and risk assessment using CEM to calculate steady state air concentrations based on a range of weight fractions in a toy and surface area for an infant exposure scenario. As noted in Section 5.2, the HEC for non-cancer chronic exposure scenario is 5.5 mg/m^3, which is protective of sensitive populations, including infants (U.S. EPA, 2025y), with a total UF (*i*.e., benchmark) of 30. EPA then calculated MOEs using this HEC and air concentration from CEM and compared MOEs to the benchmark of 30 for non-cancer risk estimates to determine if there is a threshold of non-cancer risk, *i.e.*, where the MOE fall below the benchmark, based on the combinations of weight fractions and surface areas. Even at 0.3 weight fraction (30%) 1,3-butadiene concentration and a toy surface area of 4 m^2, the MOE was over 7-fold greater than the benchmark MOE (30; MOE = 236). Notably, the highest amount of 1,3-butadiene reported from systematic review in toys was a weight fraction of 5.3×10^{-6} (0.00053%) (Abe et al., 2013), which is multiple orders of magnitude lower than the modeled inputs.

In conclusion, EPA did not find appreciable risk to the consumer—even when exaggerated weight fractions were input into the model; therefore, the Agency does not expect unreasonable risk to consumers from residual 1,3-butadiene monomer in consumer products. For more details on the modeling approach and methodology, see Appendix I.

5.3.4 Risk Estimates for General Population

As detailed in Section 4.2.1 of the *General Population Exposure for 1,3-Butadiene*, EPA conducted a quantitative exposure assessment for the air pathway using a tiered approach to evaluate non-cancer and cancer risks for the general population. For the tier I analysis, EPA used the IIOAC Model to estimate 1,3-butadiene ambient air concentrations across radial distances between 100 to 1,000 m from release points using industry-reported release data from TRI (2016–2021) and presented a range of modeled concentrations across all reporting years for each facility. The ambient air concentrations modeled with IIOAC were used for the risk calculations for chronic non-cancer MOEs and inhalation cancer risk estimates.

Based on the tier I results from IIOAC, non-cancer risks were not expected for the general population. However, there were cancer risk estimates at or above 1 in a million. Therefore, EPA moved forward to a tier II analysis and used HEM to refine 1,3-butadiene ambient air concentrations and inhalation cancer risk estimates across radial distances between 10 to 50,000 m from TRI facility releases. In response to SACC and public comments, aggregate non-cancer risks were also considered based on the HEM radial distance modeled concentrations.

In addition to modeling ambient air concentrations at radial distances, HEM was used to model annual average ambient air concentrations and calculate cancer risk estimates at the centroid of census blocks within 50,000 m from TRI facility release points. Census block-based results are aggregated across facilities; that is, if there are two or more facilities within 50,000 m from a census block then the modeled concentrations from each facility release are added together to calculate an aggregate cancer risk estimate at that census block.

Based on the tier II results from HEM, aggregate non-cancer risks were not expected for the general population. However, there were cancer risk estimates at or above 1 in a million. Therefore, EPA moved forward to a tier III analysis and used the HEM to model with NEI release data which refined the facility level TRI releases to process level (emission unit level) NEI releases. The tier III analysis consisted of using a subset of the 2017 and 2020 NEI facility releases; corresponding to the TRI facilities that resulted in census block cancer risk estimates above 1 in a million in the tier II analysis. Using those facilities' emission unit-specific parameters as inputs into the HEM model provides further refined modeling and risk estimate results. Additional demographic-specific population and cancer risk estimates are presented in Table_Apx H-14 and Table_Apx H-15. The *General Population Exposure for 1,3-Butadiene* TSD describes the tiered approach EPA used for this 1,3-butadiene general population risk assessment results for the tier I IIOAC and tier II HEM TRI analyses.

5.3.4.1 Tier III: HEM Inhalation Risks from NEI Releases

Because cancer risk estimates based on HEM modeling with the TRI dataset were at or above 1 in a million, EPA conducted a refined tier III analysis using HEM with the NEI dataset for the 60 TRI facilities that resulted in census block cancer risk estimates at or above 1 in a million, as identified in the tier II analysis. The Agency selected these TRI facilities for further refined modeling based on the census block cancer risk estimates rather than radial distance risk estimates. This is because the census block estimates consider actual populations residing within proximity to these facilities based on the 2020 U.S. Census data while radial distances often require further investigation to determine whether populations actually reside at those radial distances. For characterizing risk estimates for the general population, EPA focused on the NEI-based census block aggregated risk estimates rather than NEI-based radial distance risk estimates. See Section 7.1.5 for more details on the risk determination for the general population. However, EPA includes the radial distance results with the NEI release data in Appendix H.1.4.1.

Although both the TRI and NEI datasets include facilities reporting releases of 1,3-butadiene to the ambient air, these two datasets are distinctly different datasets that do not fully align when trying to cross-reference 60 facilities reporting to TRI with the same facilities reporting to NEI. In some instances, a facility may report to TRI but not NEI (or report to NEI but not TRI) due to reporting requirements. Additionally, though a facility may report to both TRI and NEI, the reported releases may vary slightly across the datasets due to differences in reporting requirements such that some facilities may report higher or lower releases to one database relative to the other. Out of the 60 TRI facilities with cancer risk estimates at or above 1 in a million, EPA was able to align 51 facilities reporting to both TRI and NEI for this refined analysis. The Agency also identified an additional four facilities from the NEI dataset from the previous March 2025 sensitivity analysis (EPA-HQ-OPPT-2024-0425-0062), which either resulted in cancer risk estimates greater than those based on the TRI dataset or did not report to TRI. This resulted in a total 55 facilities modeled in this tier III analysis. A list of all facilities evaluated for this analysis is provided in Table_Apx H-10. The nine TRI facilities that did not have NEI 2017 or 2020 release data were not included in the tier III analysis but are discussed at the end of Section 5.3.4.1.1.

One additional refinement for this tier III analysis is that EPA used the latest version of HEM (HEM v5.0; accessed December 5, 2025), which was released in March 2025 after the publication of the *Draft*

Risk Evaluation for 1,3-Butadiene (U.S. EPA, 2024b). Some key updates for HEM v5.0 include the following: the latest version of the American Meteorological Society/Environmental Protection Agency Regulatory Model (AERMOD), access to USGS online web services for elevation data, and the ability to assign receptor height above ground level (flagpole height)—all of which influence the modeling results compared to HEM v4.2. See Appendix H.1 for details on HEM inputs for NEI releases used in the tier III analysis.

5.3.4.1.1 Tier III: Cancer Risk Estimates by Census Blocks from NEI Releases

In the tier III analysis, EPA modeled releases using NEI 2017 and 2020 release data, which allow for emission unit-specific input parameters into the HEM for the 55 NEI facilities identified in Section 5.3.4.1. EPA then aggregated and summarized cancer risk estimates at the facility and census block levels for the 55 NEI facilities. This allowed EPA to characterize exposures and associate risks by COUs/OESs, though this introduces some uncertainty within the aggregated results because a single facility may have multiple processes which are categorized into different COUs/OESs but are aggregated together under a single COU/OES based on the primary North American Industry Classification System (NAICS) for the facility. Table 5-6 summarizes the number of facilities by COU/OES, the cancer risk estimate ranges by COU/OES, and the number facilities within each COU/OES that resulted in risk estimates at or above 1 in a million (1×10^{6}) and 1 in 100,000 (1×10^{6}). The first four columns provide the life-cycle information through COU/OES, tabulates the number of modeled facilities, the range of the maximum cancer risk estimates for all the modeled facilities, and the number of facilities with cancer risks estimates at or above 1 in a million—all categorized by COUs/OESs. The next column summarizes the total number of facilities categorized into each COU/OES that had NEI-reported releases in the dataset evaluated. The next two columns summarize the range of cancer risk estimates across all census blocks within 50 km of all facilities categorized into the respective COU/OES.

Using the manufacturing COU/OES as an example to read-across, Table 5-6 shows the manufacturing COU/OES includes 17 of the 55 NEI facilities modeled in the tier III analysis. The range of cancer risk estimates across all census blocks within 50 km for all facilities categorized under the manufacturing COU/OES was 3.1×10^{-11} to 1.2×10^{-5}. Continuing across the manufacturing row, 9 out of the 17 manufacturing facilities modeled have cancer risk estimates at or above 1 in a million and 1 out of 17 manufacturing facilities modeled have cancer risk estimates at or above 1 in 100,000.

Looking across the entirety of the tier III analysis results, the range of cancer risk estimates across all 55 NEI facilities and COUs/OESs was 3.1×10^{-11} to 3.4×10^{-5}. The maximum facility cancer risk estimate is associated with the Plastics and rubber polymerization COU/OES and represents the highest cancer risk estimate modeled at a receptor (*e.g.*, census block centroid receptor, out of all the receptors modeled within 50 km from that facility). Altogether, 30 out of the 55 NEI facilities evaluated resulted in cancer risk estimates at or above 1 in a million.

Based on the general population IUR of 5.8×10^{-6} risk per µg/m^3, exposure concentrations of 0.172 µg/m^3 (7.77×10^{-5} ppmv) or greater will result in a cancer risk estimate at or above 1 in a million. For all census blocks modeled, HEM utilized population counts within each census block where risk estimates were at or above 1 in a million across the United States to calculate a total estimated population count with risk estimates at or above 1 in a million. Based on the multi-facility aggregate census block cancer risk estimate results, there is a total population of 64,384 people with an aggregate cancer risk estimate at or above than 1 in a million and 372 people with an aggregate cancer risk estimate at or above 1 in a 100,000 within 50 km from all 55 NEI facilities that reported in 2017 and/or 2020. Figure 5-1 shows a map of the census block cancer risk estimates based on the 2020 NEI reporting year. Elevated cancer risk estimates are concentrated in areas along the Gulf Coast region from Texas to Louisiana—primarily between Houston and Baton Rouge shown in the zoomed-in map (Figure 5-2). Figures for the 2017 NEI reporting year are presented in Appendix H.

Census block ID 114022071 with a population of seven people had the highest aggregate cancer risk estimate of 3.4×10^{-5} (3.4 in 100,000) at the census block centroid receptor. This census block is in Beaumont, Texas, with 20 of the 55 modeled NEI facilities releasing 1,3-butadiene located within 50 km. Although 20 facilities contribute to the aggregate cancer risk estimate at this census block, a single facility contributes about 100 percent of the total aggregated cancer risk estimate with a facility cancer risk estimate of 3.4×10^{-5} (3.4 in 100,000). This is the closest facility of the 20 facilities; located within 500 m of this census block and is categorized under the Processing – plastics and rubber compounding COU/OES.

Census block ID 625001001 with a population of 232 people had the second highest aggregate cancer risk estimate of 2.9×10^{-5} (2.9 in 100,000) at the census block centroid receptor. This census block is in Norco, Louisiana, with 10 of the 55 modeled NEI facilities releasing 1,3-butadiene located within 50 km. Although 10 facilities contribute to the aggregate cancer risk estimate at this census block, a single facility contributes about 97 percent of the total aggregated cancer risk estimate with a facility cancer risk estimate of 2.8×10^{-5} (2.8 in 100,000). This is the closest facility of the 10 facilities; located within 500 m of this Census block and is categorized under the Manufacture – repackaging COU/OES.

A comparison between census block cancer risk estimates based on TRI and NEI releases is discussed in Appendix H.2 and a comparison to other EPA risk assessments is discussed in Appendix H.3.

For HEM output modeling files based on 2017 and 2020 NEI releases for the facilities evaluated in the tier III analysis, see *Supplemental Information on the Human Exposure Modeling Results for 1,3-Butadiene (NEI)* (U.S. EPA, 2025ai).

EPA acknowledges that there were nine TRI facilities with cancer risk estimates above 1 in a million that did not have corresponding NEI releases data, and therefore were not included in this tier III analysis. The impact of releases from these TRI facilities on the aggregate cancer risk estimates for census blocks calculated using releases from NEI facilities is unknown but will depend on the geographic proximity of these 9 facilities in relation to the 55 NEI facilities that were modeled. As such, EPA evaluated the location of the census block that resulted in the highest aggregate cancer risk estimates (Census block ID 625001001, located in Norco, Louisiana) in relation to the nine TRI facilities that were not included in the tier III analysis. The closest TRI facility to this census block is approximately 170 miles (273.5 km) away (TRI ID 7066WLSNNT221LD located in Lake Charles, Louisiana), which is beyond the 50 km aggregate range used in HEM. In addition, this facility had a maximum cancer risk estimate of 1.4×10^{-6} (1.4 in 1,000,000), which is an order of magnitude lower than the highest NEI-based census block aggregate risk estimate. Therefore, EPA concluded that there would not be a significant difference in the highest census block aggregate risk estimates based on NEI releases even if the nine TRI facilities were included in this tier III analysis.

Table 5-6. Inhalation Cancer Risk Population Count Based on HEM Modeling Results Using 2020 Census Blocks for NEI 2017 and 2020 Releases

Condition of Use			OES	Facility Count	Range of Maximum Facility Cancer Risks		Facility Count with ≥ 1 in 1,000,000 Risk (1E−06)	Facility Count with ≥ 1 in 100,000 Risk (1E−05)
Life Cycle Stage	Category	Subcategory			Min	Max		
Manufacture	Domestic manufacturing	Domestic manufacturing	Manufacturing	17	3.1E−11	1.2E−05	9	1
Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber polymerization	19	2.6E−07	3.4E−05	14	2
Processing	Processing –incorporation into article	Other: monomer in: Rubber and plastic product manufacturing	Plastics and rubber compounding and converting	1	9.0E−07	9.0E−07	0	0
Processing	Processing –incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	2	3.2E−07	9.0E−07	0	0
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	Processing as a reactant	13	3.7E−08	1.6E−05	5	1
Manufacturing	Import	Import	Repackaging	3	1.5E−07	2.8E−05	2	1
Processing	Repackaging	Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing						
			Total	**55**			**30**	**5**

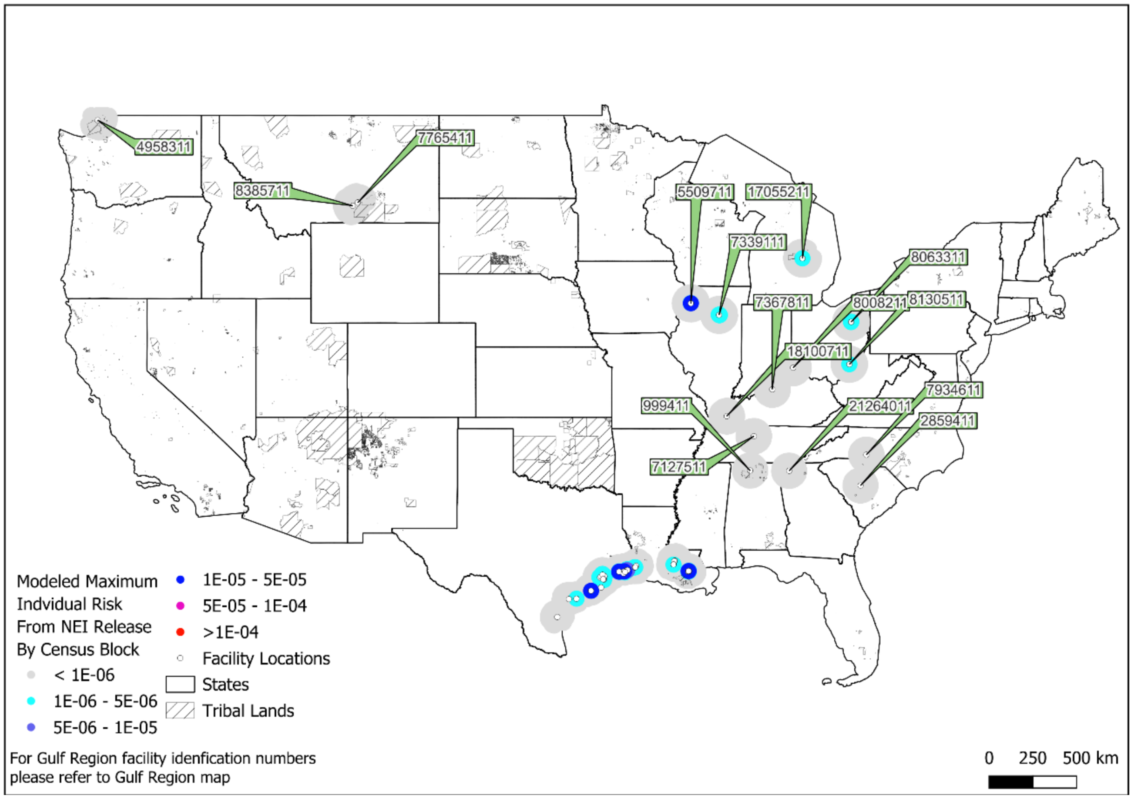

Figure 5-1. US Census Block Risk Estimates Based on 2020 NEI Releases

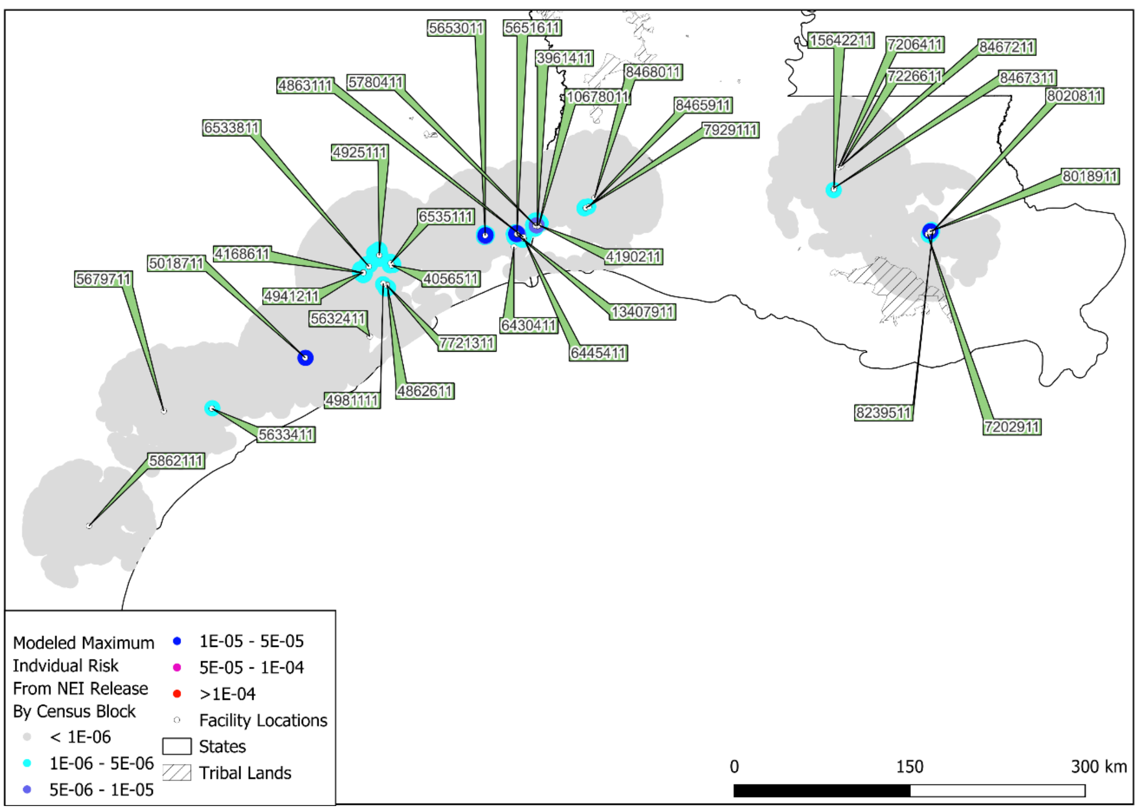

Figure 5-2. Texas and Louisiana Census Block Risk Estimates Based on 2020 NEI Releases

5.3.5 Risk Characterization for Potentially Exposed or Susceptible Subpopulations

For the 1,3-butadiene risk evaluation, EPA considered information that could support increased exposure or biological susceptibility compared to the general population (Table 5-7; see Appendix D for full list of factors). EPA was able to incorporate considerations for multiple PESS factors into risk estimates, as presented in Table 5-7. The Agency considered these PESS factors through the use of exposure factors, UFs, and PESS group-specific data. In some cases, information on PESS factors may have supported the weight of scientific evidence for a particular hazard or exposure value. For the non-cancer health endpoint, EPA performed dose-response analysis for multiple repeat-dose non-cancer endpoints under each hazard domain. Decreased fetal weight associated with other developmental toxicity outcomes was selected as the most sensitive and robust, human-relevant endpoint for use in risk characterization of intermediate and chronic exposures.

For the cancer health endpoint, EPA used an occupational epidemiological cohort, comprising male and female workers, with more than 50 years of follow-up and subsequent exposure estimate updates to derive inhalation hazard values for leukemia and bladder cancer applicable to general population and occupational exposures. Due to an identified mutagenic mode of action for cancer, EPA applied an ADAF for the general population to account for elevated childhood susceptibility. The combination of using the most sensitive endpoint protective of the pregnant worker, robust evidence from a large, highly exposed occupational human cohort tracked over many decades along with the application of an ADAF, allows the derived hazard values used for non-cancer and cancer risk characterizations to fully account for PESS. Full details on all available information relating to biological susceptibility are presented in Section 7.2 of the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y)—including PESS factors with only indirect evidence or otherwise insufficient information to incorporate into hazard or risk values.

For the general population risk characterization, subpopulations that live within 5,000 m (3 miles) of the 55 NEI facilities were considered PESS due to their close proximity to 1,3-butadiene facility releases. See Potentially Exposed or Susceptible Subpopulations

Table_Apx H-14 and Table_Apx H-15 for a presentation of (1) the demographic breakdown for all census blocks within 5,000 m from the 55 NEI facilities, and (2) average cancer risks and percentage of the subpopulations at risk categorized by age, education, and other sociodemographic factors, including poverty and disabilities. The average cancer risk estimates for these subpopulations ranged from 0.3 to 0.6 in a million, with an overall average cancer risk estimate of 0.3 in a million, which is an additional 0.3 cancer cases per 1 million people exposed over a lifetime. In total, there are 1,056,352 people who are living within 5,000 m of any of the 55 NEI facilities. Of the 1,056,352 people, 60,786 people live in a census block that resulted in a cancer risk estimate at or above 1 in a million. As previously mentioned, there is a total population of 64,384 people with a cancer risk estimate at or above 1 in a million within 50 km from any of the 55 NEI facilities, demonstrating that 94.4 percent (60,786 out of 64,384 people) of the population with a risk estimate at or above 1 in a million reside within the first 5 km of a 1,3-butadiene-releasing facility. This cancer risk from exposure to 1,3-butadiene released from TSCA facilities can be contextualized as 0.06 extra cases in this population; 9×10^{-4} (0.0009) additional case per year when assuming a 70-year lifetime for this population; or 1 additional case within this population every 1,150 years.

Table 5-7. Summary of PESS Factors Incorporated into Risk Estimates

PESS Factor	Potential Increased Exposures Incorporated into Exposure Assessment	Sources of Uncertainty for Exposure Assessment	Potential Sources of Biological Susceptibility Incorporated into Hazard Assessment	Sources of Uncertainty for Hazard Assessment
Life stage	• Life stage-specific exposures were not incorporated into the risk evaluation.	• Exposures were quantified as air concentrations and not internal dose. However, UF_H is expected to account for any toxicokinetic differences (U.S. EPA, 2012a).	• Direct evidence of a developmental effect was the basis for the intermediate/chronic POD used for risk estimation. • Increased susceptibility of children to cancer was addressed by incorporation of an ADAF into the general population IUR.	• EPA expects that this PESS factor is sufficiently accounted for in risk estimates.
Pre-existing disease	*Not applicable*	*Not applicable*	• Application of a 10× UF_H to account for human variability.	• Especially susceptible individuals may not be accounted for by standard approaches.
Occupational and consumer exposures	• Occupational exposure sampling data were broken down into subsets of worker roles that identify higher exposure activities. • Worker exposures and hazard values incorporated adjustments for relative breathing rate per day of exposed workers compared to the general population.	• The majority of occupational exposure sampling data points used in generating estimates of occupational exposure were not quantifiable values but were identified as being below the LOD. • Exposure factors change over time and differing assumptions may result in risk estimates varying by up to 30%.	*Not applicable*	*Not applicable*
Geography/site-specific	• Populations who reside nearby facility releases of 1,3-butadiene were taken into consideration with modeled exposure concentrations by distance	• The estimates of risks via ambient air are dependent on inputs and assumptions described in Section 2 of the *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u) and calculations based on census data and equations from the HEM as detailed in the HEM User's Guides (accessed December 5, 2025)	*Not applicable*	*Not applicable*
Sociodemographic Status	• Cancer risks were estimated for various demographics.	• The estimates of risks via ambient air are dependent on inputs and assumptions described in Section 2	• EPA utilized the most sensitive sex from rodent assays for non-cancer dose-response modeling	• EPA was unable to quantify sociodemographic differences other than sex.

PESS Factor	Potential Increased Exposures Incorporated into Exposure Assessment	Sources of Uncertainty for Exposure Assessment	Potential Sources of Biological Susceptibility Incorporated into Hazard Assessment	Sources of Uncertainty for Hazard Assessment
		of the *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u) and calculations based on census data and equations from the HEM as detailed in the HEM User's Guides (accessed December 5, 2025)	and incorporated data from both sexes in cancer modeling.	
Genetics/ epigenetics	*Not applicable*	*Not applicable*	• Application of a linear low-dose cancer dose-response model should account for varying susceptibility across populations. • Application of a 10× UF_H to account for human variability.	• Hazard values are based on wild-type rodents and a broad occupational population and may underestimate risks for populations with sensitizing mutations.
Aggregate exposures	• Cancer risks were estimated based on aggregate modeled exposure concentrations at census blocks • Non-cancer risks were estimated based on aggregate modeled exposure concentrations at 100-meter radial distance	• The estimates of exposure via ambient air are dependent on inputs and assumptions described in Section 2 of the *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u)	*Not applicable*	*Not applicable*

ADAF = age-dependent adjustment factor; HEM = Human Exposure Model; IUR = inhalation unit risk; LOD = limit of detection; PESS = potentially exposed and susceptible subpopulations; POD = point of departure; UF = uncertainty factor

5.3.6 Risk Characterization for Aggregate Exposures

Section 2605(b)(4)(F)(ii) of TSCA requires EPA, as a part of the risk evaluation, to describe whether aggregate or sentinel exposures under the COU were considered and the basis for their consideration. Furthermore, in the final RE framework rule, EPA codified at 720.39(d)(8), a requirement that "EPA will consider aggregate exposures to the chemical substance, and, when supported by reasonably available information, consistent with the best available science and based on the weight of scientific evidence, include an aggregate exposure assessment in the risk evaluation, or will otherwise explain in the risk evaluation the basis for not including such an assessment." In response to the SACC and public comments, EPA included an aggregate non-cancer risk estimate by aggregating modeled concentrations from several facilities within a 10 km radius to calculate an aggregate MOE, which was above the benchmark. Therefore, indicating that EPA does not expect non-cancer risks from inhalation exposure to 1,3-butadiene from facility releases. See Section 2.2.1.2.1 of the *General Population Exposure for 1,3-Butadiene* (U.S. EPA, 2025u).

EPA quantified aggregate cancer risk estimates for TRI and NEI reporting facilities at the census block level resulting from multiple facilities in proximity. The highest aggregate risk estimates based on modeled air concentrations were focused along the Texas and Louisiana Gulf Coast (Figure 5-2). AMTIC monitoring stations report air concentrations of ambient 1,3-butadiene from all sources, including fuel combustion. Monitoring data provide an indication of the aggregate risk from all sources contributing to ambient air concentrations of 1,3-butadiene, which may be present in the real world and provide context for risks from individual COUs. The modeled and monitored air concentrations (AMTIC) are within an order of magnitude along the Texas and Louisiana Gulf Coast, indicating that the modeled numbers used for risk evaluation capture aggregate 1,3-butadiene exposure in the region of the United States showing highest risk estimates.

5.3.7 Overall Confidence and Remaining Uncertainties in Human Health Risk Characterization

There is robust confidence in the human health hazard values for both non-cancer and cancer endpoints (see Section 6 of the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y)). The non-cancer HEC is supported by multiple effects observed at similar doses across studies at relevant exposure durations and despite large differences in metabolism across species, maternal-developmental effects were observed in both mice and rats (see Sections 4.2.1.2 and 4.2.2.2.3 of (U.S. EPA, 2025y)). The general population cancer IUR/chronic occupational unit risk is based on a large occupational human cohort tracked over several decades with robust evidence for the leukemia and bladder cancer endpoint (see Sections 5.3.1.1 and 5.3.2 of (U.S. EPA, 2025y)).

5.3.7.1 Occupational Risk Characterization

For this 1,3-butadiene risk evaluation, EPA has moderate to robust confidence in the inhalation exposure data for most OESs. Several studies of 1,3-butadiene exposure were directly applicable to OESs within the assessment and used to estimate inhalation exposures. Additionally, inhalation exposure data collected during OSHA enforcement activities provided additional sampling data across several industries and COUs. The primary strength of this data is the use of personal and applicable data that received a high rating during systematic review and/or data used in enforcement proceedings. There was lower confidence in the OESs of Application of paints and coatings and the Application of adhesives and sealants due to all measurements being below the LOD, as well as for Recycling and Waste handling, treatment, and disposal, due to a small sample size for the dataset with only one quantified data point.

The primary limitations to these data include the uncertainty of the representativeness of the exposures in specific industries, uncertainty in the representativeness of the data towards the true distribution of inhalation concentrations in this scenario, that the data come primarily from one industry source, and that much of the data for both workers and ONUs from the source were reported as below the LOD. When a reported monitoring data point was a non-detect, EPA estimated the exposure concentrations for these data using either the statistical analysis of MLE, or the substitution method detailed in the Agency's *Guidelines for Statistical Analysis of Occupational Exposure Data* (accessed December 8, 2025), depending on the number of detected samples in the dataset. There is higher confidence in exposure results analyzed via MLE as these had sufficient sample size for robust statistical analysis. EPA also assumed 250 exposure days per year for routine 8-hour shifts based on 1,3-butadiene exposure each working day for a typical worker schedule consistent with the OSHA PEL and other OELs; it is uncertain whether this captures actual worker schedules and exposures. While for many COUs, the majority of monitored values were non-detects, high-end (95th percentile) values were typically based on measured, recorded values above the LOD. Central tendency estimates incorporated both measured values and statistical adjustments for non-detects. Exposure values were based on single-day measurements that were extrapolated to represent average daily concentrations over the specified duration. Therefore, high-end exposures and risk estimates are most appropriate for consideration of shorter-duration exposures (*i.e.*, intermediate) while central tendency values are more representative for chronic and lifetime exposures.

Based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for the occupational exposure assessment overall is moderate and provides a plausible estimate of exposures in consideration of the strengths and limitations of reasonably available data. There is reduced confidence in conclusions of potential risks when risks relative to benchmark are indicated only at higher-end exposures. As stated above, this is especially true for cancer, which is based on average exposure across a lifetime, in contrast with intermediate exposures for which higher-end measurements are more applicable. Additionally, for these scenarios there is robust confidence when high-end exposures did *not* indicate risk relative to benchmarks. For example, EPA had the lowest confidence for exposure estimates from Application of paints, coatings, adhesives, and sealants because all associated data points were below the LOD. However, because potential risk was not identified for this OES, even at high-end exposure set equivalent to the LOD, EPA has robust confidence that risk is not associated with this COU or OES. Confidence is also downgraded when ONU data were not available; in such cases, EPA assumed that the central tendency worker value was an appropriate approximation for ONUs, but the validity of this assumption is likely to vary widely across COUs and SEGs.

The consideration of exposure controls and PPE usage has relatively high uncertainty. EPA has information on the range of exposure controls and respirators used for various tasks in the manufacturing and processing as a reactant COUs. However, the effect of engineering controls cannot be quantified, and the Agency can only confidently calculate reduced risk estimates from respirator usage assuming perfect use throughout an entire shift. The available information does not cover all COUs or even all facilities within those COUs, and even individual tasks have a reported wide range of respirator use (ranging from no respirator to supplied air), indicating that the potential exposure may vary for the individual tasks.

There is moderate to robust confidence in the risk estimates relative to benchmarks (*e.g.*, whether risk is indicated or not) for the two OESs with the highest exposure: Repackaging, and Plastics and rubber polymerization. The Repackaging OES exposure estimates, using the full shift assumption (the measured task-length exposures occur for the entire length of a shift), resulted in risk estimates that indicate risk relative to benchmark for both central tendency and high-end estimates without the consideration of PPE. When considering PPE, risk was mitigated for the central tendency exposure scenario but not for the high-end. Risk was indicated relative to benchmark at high-end exposures, even when using the task-length assumption (the measured task-length exposure occurs for the indicated duration and there is no exposure for the remainder of the shift). This risk was mitigated with the consideration of PPE.

The Plastics and rubber polymerization OES exposure estimates using published summary exposure data resulted in risk estimates that indicate risk relative to benchmark for both central tendency and high-end estimates without the consideration of PPE. The risk was mitigated using a respirator with an APF of 50 for the central tendency but not the high-end exposure scenario.

Refinements of the risk estimates may inform risk management for these cases.

Details for confidence in the exposure assessment for other OESs are summarized in Section 5.1.1.2. For more detail, see the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r).

5.3.7.2 Consumer Risk Characterization

As described in Section 5.3.3, EPA demonstrated that risk estimates are above the non-cancer benchmarks and below cancer benchmarks—even with highly conservative estimates of weight fraction. Additionally, the Agency calculated risks based on elevated infant doses compared to adults (based on breathing rate/body weight ratio), despite that the most sensitive non-cancer POD was a developmental effect that applies to pregnant women. EPA therefore has very robust confidence that there is (1) minimal risk to consumers from 1,3-butadiene from any consumer products, and (2) these exposures do not significantly contribute to unreasonable risk.

5.3.7.3 General Population Risk Characterization

Based on the weight of scientific evidence for general population exposures detailed in Section 5.1.3.2 and for human health hazard in Section 5.2.1; the high-rated quality of environmental release data across multiple years and from multiple datasets (TRI and NEI) combined with the use of peer-reviewed models to assess general population exposure; and the robust human, animal, and mechanistic evidence associating leukemia and other lymphohematopoietic cancers with 1,3-butadiene exposure, EPA has robust confidence in the general population risk characterization. The use of HEM risk results based on census block information, incorporating population count and sociodemographic data as well as providing geospatial visualizations, allows for a representative estimation of exposure concentrations and risk for the general population. However, a source of uncertainty exists in that the risk estimates based on census block centroid receptors used in the HEM may not be representative for all populations residing in that census block due to geospatial variability of residential homes within that census block. In addition, U.S. Census data may undercount certain sociodemographic groups, which leads to uncertainty in estimates for those groups.

EPA also acknowledges that the assumptions made for the general population being exposed to modeled ambient air concentrations 24 hours a day, 365 days a year, over a lifetime likely leads to overestimates of risk. There is also uncertainty as to whether risk is underestimated or overestimated due to photodegradation of 1,3-butadiene not being accounted for in this risk evaluation, though any potential risk to degradants (acrolein, formaldehyde) is also not accounted for so this uncertainty may be canceled out. In addition, EPA acknowledges the uncertainty associated with the use of TRI and NEI annual release data and the number of days of operation to determine the same daily release every day of operation. This approach may miss peak daily releases that can occur when operations fluctuate across different days and can impact short-term exposure estimates. However, this approach is appropriate and less uncertain for chronic exposures and risk estimates over a lifetime because it considers consistent long-term exposure effects and is less influenced by short-term exposures.

6 ENVIRONMENTAL RISK ASSESSMENT

1,3-Butadiene – Environmental Risk Assessment (Section 6):
Key Points

EPA evaluated the reasonably available information for environmental exposures to 1,3-butadiene. The key points of the environmental exposures and hazards assessment are summarized below.

- Although 1,3-butadiene may be released to water, land, and air, 1,3-butadiene concentrations were not modeled for the surface water and land pathways because 1,3-butadiene is primarily released as a gas to air. It is not expected to persist in soil and water based on its physical and chemical properties as well as environmental fate and transport characteristics.
- EPA qualitatively assessed environmental exposures of 1,3-butadiene in water and soil.
  - 1,3-Butadiene is not expected to be present in surface water given minimal releases to surface water, rapid biodegradation, and volatilization. Additionally, 1,3-butadiene has low sorption potential and is not expected to be present in sediment.
  - 1,3-Butadiene is not released to soil and air to soil deposition is not expected due to the physical and chemical properties (high volatility and reactivity and low sorption to organic material).
- 1,3-Butadiene releases in air are expected to be the predominant pathway of environmental exposure.
  - Extensive ambient air monitoring data are available for 1,3-butadiene and confirms that air is the primary exposure pathway.
  - Although these data demonstrate 1,3-butadiene concentrations in ambient air, their source is unknown. Concentrations of 1,3-butadiene in ambient air are likely from a combination of TSCA and other sources (*e.g.*, forest fires, mobile exhaust).
  - EPA summarizes available 1,3-butadiene ambient air monitoring data in this assessment.
- There is no expected risk to aquatic organisms as 1,3-butadiene is not appreciably released to and does not persist in surface water; thus, exposure is not expected.
- There is no expected risk to terrestrial organisms through soil exposure as 1,3-butadiene does not partition, deposit, or persist in or on land and exposure is not expected.
- Although exposure of 1,3-butadiene to terrestrial organisms is expected via ambient air, exposures will be transient due to the reactive nature of 1,3-butadiene. Furthermore, 1,3-butadiene exposure in ambient air cannot be attributed to a specific TSCA use.
- A screening analysis of potential risk to terrestrial organisms via ambient air exposure was conducted with the following results:
  - The most sensitive toxicity endpoint for terrestrial vertebrate exposure to 1,3-butadiene via inhalation was 20 ppm (44,240 µg/m^3).
  - The highest ambient air concentration modeled was 386.4 µg/m^3 1,3-butadiene within 100 m away from the facility release point; and the highest concentration of 1,3-butadiene from ambient air monitoring data was 267.3 µg/m^3.
  - Given that the highest modeled and monitored concentrations of 1,3-butadiene in ambient air are two orders of magnitude lower than the most sensitive toxicity endpoint, risk to terrestrial organisms via air exposure is expected to be negligible.

6.1 Summary of Environmental Exposures

6.1.1 Summary of Exposures to Aquatic Species

1,3-Butadiene is not expected to be present in surface water due to its physical and chemical properties (gas form under ambient conditions, high volatility and reactivity, low sorption potential) per the *Physical Chemistry, Fate, and Transport Assessment* (U.S. EPA, 2025ae)). 1,3-Butadiene releases to surface water are minimal (*Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)). Additionally, monitoring results from WQP indicate all surface water samples (n = 231) were below detection limits for 1,3-butadiene (0.04 mg/L) (*Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q)). Thus, multiple lines of evidence demonstrate that 1,3-butadiene will not be present in surface water and aquatic organisms will not be exposed to 1,3-butadiene.

6.1.2 Summary of Exposures to Terrestrial Species

Releases of 1,3-butadiene to land make up less than 1 percent of 1,3-butadiene releases to the environment, and most land releases are to class I underground injection wells (*Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)). Class I wells are typically drilled thousands of feet below any drinking water aquifers and are constructed to contain injected waste streams and prevent movement into water systems or soil. Terrestrial organisms will not be exposed to 1,3-butadiene via the land pathway (soil, biosolids) based on the low volume of releases to land, the low risk of failure of class I injection wells, the physical and chemical properties of 1,3-butadiene (*i.e.*, low sorption potential), as well as monitoring data indicating less than 1 percent detection frequency (see *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* and *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q, 2025ae)).

Extensive ambient air data, both measured data and monitoring data, are available for 1,3-butadiene and confirm that air is the primary exposure pathway. Terrestrial organisms are likely exposed to 1,3-butadiene in air; however, the sources of 1,3-butadiene in ambient air are a combination of TSCA and other sources (*e.g.*, forest fires, mobile exhaust, etc.). EPA summarizes available 1,3-butadiene ambient air measured concentrations and monitoring data in the *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q); modeled 1,3-butadiene concentrations in ambient air from release facilities are described in the *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u). The 95th percentile modeled results from IIOAC for ambient air concentrations near industrial facilities (within 100–1,000 m) releasing 1,3-butadiene ranged from 0.0 to 109.5 µg/m^3, with the highest concentrations modeled at 100 m from facility releases. Furthermore, for all distances modeled with HEM (10–50,000 m), the 95th percentile modeled concentration ranged from 0.0 to 386.4 µg/m^3 with the highest concentrations modeled 100 m away from facility releases. See the *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u) for details of the assessment. For ambient air, concentrations from five U.S. studies ranged from 0.01 to 1.91 µg/m^3. In addition, monitoring data were extracted from EPA's AMTIC database where 24-hour concentrations ranged from 0.0 to 267.3 µg/m^3. For more details, see *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q).

6.1.3 Weight of Scientific Evidence Conclusions for Environmental Exposures

EPA uses several considerations when weighing the scientific evidence to determine confidence in the environmental risk assessment. These considerations include the quality of the database, consistency, strength, and precision, biological gradient/dose response, and relevance. This approach is consistent with the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a). EPA has robust confidence in this environmental exposure assessment.

The 1,3-butadiene data from the WQP has a strong bias of samples collected from California, New York, Texas, Georgia, North Carolina, and Florida (which represent >39% of the U.S. population) relative to other areas and was missing data from Alaska, Delaware, Rhode Island, Hawaii, and Vermont (<2% of the U.S. population). The states with a higher number of data points are states where a higher percentage of the U.S. population resides. In addition, states with a concentration of facilities releasing 1,3-butadiene, such as Texas and Louisiana, are included in the monitoring database. Due to the presence of 1,3-butadiene releasing facilities, these states would be expected to have the largest 1,3-butadiene releases. Because data reflects that 1,3-butadiene is typically not detected above the detection limit in water, EPA has robust confidence that in areas with lower releases, 1,3-butadiene will not be in the water. In addition, based on the physical and chemical properties of 1,3-butadiene and low release quantities to water and land, EPA has confidence that the WQP data are representative of the entire United States. Notably, the WQP data are not specific to COUs. Therefore, EPA has robust confidence in this environmental exposure assessment.

6.2 Terrestrial Species Environmental Hazard

There were no environmentally relevant toxicity data for wildlife or plant exposure to 1,3-butadiene in ambient air. Limited data evaluating apical endpoints (growth, mortality, reproduction) were available from human health animal models with exposure to 1,3-butadiene via inhalation. Acceptable studies containing relevant 1,3-butadiene terrestrial toxicity data evaluated effects on rats (*Rattus norvegicus*) and mice (*Mus musculus*).

Inhalation of 1,3-butadiene influenced mice reproduction when CD-1 mice were exposed for 6 h/day over 5 days at 1,3-butadiene concentrations of 200, 1,000, and 5,000 mg/L (Hackett et al., 1988). Exposed males mated with unexposed females yielded one adverse effect (increased number of dead implants per pregnancy) following exposure to 5,000 mg/L 1,3-butadiene. Early fetal death occurred in CD-1 mice following paternal exposure for 6 hours/day, 5 days/week, for 10 weeks at 125 ppm 1,3-butadiene (Brinkworth et al., 1998). No effects on mortality or body weights were observed. Similarly, no effects of 1,3-butadiene inhalation were measured in B6C3F1 mice exposed to 1,250 ppm over 6 or 12 weeks of exposure (Thurmond et al., 1986).

1,3-Butadiene has been found to be mutagenic to sperm cells at 1,250 ppm (Anderson et al., 1996) potentially affecting reproduction. 1,3-Butadiene inhalation affects sperm and spermatids with effective concentrations of 500 ppm (Pacchierotti et al., 1998).

These studies indicate some adverse effects of acute and chronic 1,3-butadiene inhalation on terrestrial vertebrates at concentrations as low as 20 ppm. However, effects measured were not on apical endpoints (growth, mortality, reproduction) relevant for environmental risk evaluation.

6.3 Environmental Risk Characterization

6.3.1 Risk Assessment Approach

EPA determined that, based on the fate properties of 1,3-butadiene (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)), an in-depth analysis of releases to water or land and associated exposures from those releases were not needed for the water or land pathways because 1,3-butadiene does not persist in either medium. EPA used information from all reasonably available sources to characterize exposure, hazard, and risk posed from 1,3-butadiene to aquatic and terrestrial organisms.

6.3.2 Risk Estimates for Aquatic Species

1,3-Butadiene rapidly biodegrades in aerobic aquatic environments and rapidly volatilizes from water to air, and is therefore not expected to persist in water (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)). Given (1) the physical and chemical properties governing the environmental fate of 1,3-butadiene in water, (2) limited release of 1,3-butadiene directly to surface water, and (3) available monitoring data demonstrating 1,3-butadiene was not detected in water, EPA does not expect that 1,3-butadiene will persist in surface water or groundwater. Therefore, EPA concludes risk is expected to be negligible to aquatic organisms for all COUs due to the lack of 1,3-butadiene exposure in water or sediment.

1,3-Butadiene is not expected to sorb to suspended solids based on its physical and chemical properties. As such, terrestrial exposures via soil and sediment are not expected and therefore not quantified. Environmental fate and transport data indicate 1,3-butadiene does not bioaccumulate (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)). Thus, there is no dietary exposure of 1,3-butadiene from aquatic organisms to terrestrial organisms and minimal risk is expected for all COUs.

6.3.3 Risk Estimates for Terrestrial Species

1,3-Butadiene does not sorb or bind to soil or sediment and does not persist on land (due to volatility and reactivity) (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)). The predominant environmental release of 1,3-butadiene to land is disposal via underground injection into wells. Therefore, there are no appreciable direct releases to land (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)). Considering these lines of evidence, 1,3-butadiene is not expected to persist in or on land. Therefore, EPA concludes there is no expected risk from any COU to terrestrial organisms via the land pathway due to no 1,3-butadiene exposure in soils. There is no expected risk from any COU via dietary exposure to terrestrial organisms as 1,3-butadiene does not bioaccumulate (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)).

Terrestrial organisms may be exposed to 1,3-butadiene via ambient air and extensive ambient air monitoring data are available. These data show that 1,3-butadiene is prevalent in ambient air and confirms that air is a major 1,3-butadiene exposure pathway. Although these data represent actual 1,3-butadiene concentrations in ambient air, the source is unknown and likely a combination of TSCA and other sources (*e.g.*, forest fires, mobile exhaust).

A potential terrestrial 1,3-butadiene exposure scenario may involve a fugitive or stack 1,3-butadiene release to ambient air from a COU that is inhaled by terrestrial organisms located in proximity to the release facility. Many terrestrial organisms are transient in the environment. As such, the aforementioned exposure scenario is most applicable to local and non-transient organisms such as plants. However, there are no available plant hazard data for 1,3-butadiene and there is uncertainty in attributing exposure to a TSCA source. Therefore, risk to terrestrial plants cannot be determined.

Limited data from human health animal toxicity studies document some adverse effects of acute and chronic 1,3-butadiene inhalation on terrestrial vertebrates at concentrations as low as 20 ppm (44,240 $\mu g/m^3$), though these effects were not on apical endpoints (growth, mortality, reproduction). The highest ambient air concentration modeled was 386.4 $\mu g/m^3$ 1,3-butadiene 100 m away from the facility release point and the highest monitored concentration in ambient air was 267.3 mg/m^3 1,3-butadiene. Given that modeled and measured 1,3-butadiene concentrations in ambient air are two orders of magnitude lower than the most sensitive toxicity endpoint available for vertebrates, risk is expected to be negligible for terrestrial organisms exposed to 1,3-butadiene from COUs.

6.3.4 Overall Confidence and Remaining Uncertainties in Environmental Risk Characterization

EPA used several considerations when weighing the scientific evidence to determine confidence in the environmental risk assessment. These considerations include the quality of the database, consistency, strength and precision, biological gradient/dose response, and relevance. This approach is consistent with the 2021 Draft Systematic Review Protocol (U.S. EPA, 2021a). EPA has robust confidence in this environmental risk assessment.

The Agency has robust confidence in the conclusion that there is no expected risk to aquatic organisms resulting from COUs. Multiple lines of evidence support this conclusion. Environmental fate and transport data indicate 1,3-butadiene is expected to have negligible persistence in water (*Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)). There are also limited releases of 1,3-butadiene directly to surface water due to COUs and available monitoring data demonstrate that 1,3-butadiene has not been detected in water.

EPA has robust confidence in the conclusion that there is no expected risk to terrestrial organisms due to COUs via the land pathway. Multiple lines of evidence support this conclusion. Environmental fate and transport data indicate 1,3-butadiene does not sorb or bind to soil or sediment and has negligible persistence on land (due to volatility and reactivity) (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)). Furthermore, 1,3-butadiene is reactive and volatile. There are also limited releases of 1,3-butadiene to land (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)). These chemical and fate properties support a robust confidence conclusion.

EPA also has robust confidence that there is no expected risk to terrestrial organisms due to COUs via the dietary pathway. Environmental fate and transport data indicate 1,3-butadiene does not bioaccumulate (see Section 3 and *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)). Because 1,3-butadiene is also not expected to persist in the water and land pathways, the potential for dietary exposure is limited. These qualities support a robust confidence conclusion.

Concentrations of 1,3-butadiene in ambient air are due to TSCA and other sources. Additional factors that can impact EPA's ability to attribute exposure for a specific terrestrial organism to a specific COU are the transient nature of most terrestrial organisms as well as the absence of specific activity pattern data of such organisms in or around a particular industrial process that could be attributed to a COU. Furthermore, there are limited hazard data available to assess potential risk to terrestrial organisms. Given that measured and modeled concentrations of 1,3-butadiene in ambient air are two orders of magnitude lower than the most sensitive toxicity endpoint in available animal data, there is moderate confidence that there is negligible risk to terrestrial organisms from ambient air exposure to 1,3-butadiene from COUs. Although sensitivities to 1,3-butadiene likely vary among taxa, no data evaluating toxicity of 1,3-butadiene to wildlife (*e.g.*, birds, amphibians, ungulates) are available.

Additional details on overall confidence and remaining uncertainties are described in the following TSDs: *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae), *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q), and *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r).

7 UNREASONABLE RISK DETERMINATION

TSCA section 6(b)(4) requires EPA to conduct a risk evaluation to determine whether a chemical substance presents an unreasonable risk of injury to health or the environment, without consideration of costs or other nonrisk factors, including an unreasonable risk to a PESS identified by EPA as relevant to the risk evaluation, under the COUs.

EPA is determining that 1,3-butadiene presents unreasonable risk of injury to health driven by identified unreasonable risk to workers under 11 COUs. The Agency did not identify unreasonable risk of injury to human health due to risk to consumers or the general population. EPA also did not identify unreasonable risk of injury to the environment due to exposures via soil, air, surface water, and sediment under the COUs. This unreasonable risk determination is based on the information in previous sections of this risk evaluation, the appendices, TSDs, and supplemental files included with this risk evaluation (see Appendix C) in accordance with TSCA section 6(b). This unreasonable risk determination and the underlying evaluation are consistent with the best available science (TSCA section 26(h)) and based on the weight of scientific evidence (TSCA section 26(i)).

As noted in the Executive Summary, 1,3-butadiene is primarily used as a chemical intermediate and as a monomer in the manufacture of polymers such as synthetic rubbers and elastomers. This involves polymerization of 1,3-butadiene with itself or with other monomers, then this polymerization product is incorporated into various rubber and plastic articles. Consistent with these properties, existing assessments (OEHHA, 2013; ATSDR, 2012; Grant et al., 2010; U.S. EPA, 2002a) concluded that inhalation is the predominant route for human exposures and 1,3-butadiene exposure has not been quantified by any other routes. Additional sources of 1,3-butadiene exposure come from vehicle exhaust, tobacco smoke, burning wood, and forest fires.

The COUs evaluated for 1,3-butadiene are listed in Table 2-1. EPA is determining that the following 11 COUs significantly contribute to unreasonable risk of injury to human health due to non-cancer risks from intermediate inhalation exposure to workers:

- Manufacturing – domestic manufacturing;
- Manufacturing – importing;
- Processing as a reactant – intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing);
- Processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – plasticizer (asphalt paving, roofing, and coating materials manufacturing);
- Processing – incorporation into article – monomer (rubber product manufacturing);
- Processing – use-non-incorporative activities – fuel (petroleum refineries);
- Processing – repackaging – (wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing);
- Processing – recycling; and
- Disposal.

EPA is determining that the following three COUs also significantly contribute to unreasonable risk of injury to human health due to cancer risks from chronic inhalation exposure to workers:

- Processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing);
- Processing – repackaging – (wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing);
- Processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing); and
- Disposal.

EPA is determining that the following COU also significantly contributes to unreasonable risk of injury to human health due to both non-cancer and cancer risks from intermediate and chronic inhalation exposure to ONUs:

- Processing – repackaging – (wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing).

EPA did not identify an unreasonable risk of injury to health or the environment from activities associated with the following 19 COUs:

- Processing – incorporation into formulation, mixture, or reaction product – intermediate (petrochemical manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – other (oil and gas drilling, extraction, and support activities);
- Distribution in commerce;
- Industrial use – adhesives and sealants;
- Commercial use – fuels and related products;
- Commercial use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);
- Commercial use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);
- Commercial use – synthetic rubber;
- Commercial use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles;
- Commercial use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft);
- Commercial use – other use – laboratory chemicals;
- Commercial use – lubricants and lubricant additives;
- Commercial use – paints and coatings;
- Commercial use – adhesives and sealants;
- Consumer use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);
- Consumer use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);
- Consumer use – synthetic rubber;
- Consumer use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles; and

- Consumer use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft).

This unreasonable risk determination is based on the information provided in previous sections of this risk evaluation, the appendices, TSDs, and supplemental documents (see Appendix C), in accordance with TSCA section 6(b). This risk evaluation discusses important assumptions and key sources of uncertainty in the risk characterization; these are described in more detail in the respective weight of scientific evidence conclusions sections for fate and transport (Section 3.2), environmental releases and concentrations (Sections 4.1.1.2 and 4.2.2), occupational exposures (Section 5.1.1.2), general population exposures (Section 5.1.3.2), human health hazards (Section 5.2.1), human health risk characterization (Section 5.3.7), environmental risk characterization (Section 6.3.4), and Appendix F. It also includes overall confidence and remaining uncertainties sections for human health and environmental risk characterizations. In general, EPA makes an unreasonable risk determination based on risk estimates that have an overall confidence rating of moderate or robust because those confidence ratings indicate the scientific evidence is adequate to characterize risk estimates despite uncertainties or is such that it is unlikely the uncertainties could have a significant effect on the risk estimates.

EPA will initiate risk management for 1,3-butadiene by applying one or more of the requirements under TSCA section 6(a) to the extent necessary so that 1,3-butadiene no longer presents an unreasonable risk. The Agency expects risk management requirements to focus on those COUs that drive the determination of unreasonable risk under TSCA section 6(a). EPA may select from among a suite of risk management options related to manufacture (including import), processing, distribution in commerce, commercial use, and disposal to address the unreasonable risk. The Agency could also consider whether such risk may be prevented or reduced to a sufficient extent by action taken under another federal law such that referral to another agency under TSCA section 9(a) or use of another EPA administered authority to protect against such risk pursuant to TSCA section 9(b) may be appropriate.

7.1 Unreasonable Risk to Human Health

Calculated risk estimates (MOEs[5] or cancer risk estimates) can provide a risk profile of 1,3-butadiene by presenting a range of estimates for different health effects for different COUs. When characterizing the risk to human health from occupational exposures during risk evaluation under TSCA, EPA conducts baseline assessments of risk and makes its determination of unreasonable risk in a manner that takes into consideration reasonably available information (*e.g.*, information submitted by manufacturers and processors of 1,3-butadiene; multiple, representative site visits) regarding whether use of respiratory protection or other PPE is standard practice at all sites.[6] This allows EPA to make unreasonable risk determinations based on the information regarding workers wearing PPE where the Agency has confidence that the information is representative. In addition, the risk estimates are based on exposure scenarios with monitoring data that reflect existing requirements, such as those established by OSHA or industry or sector best practices. In this risk evaluation, the risk estimates calculated reflect use both with and without PPE—including information on PPE that could be used to reduce the exposures. EPA has limited information regarding appropriate use of PPE under the COUs. Where reasonably available information suggests that existing PPE use is already occurring and is protective under a COU, this is considered in EPA's occupational risk determination in Section 7.1.3.

[5] EPA derives non-cancer MOEs by dividing the non-cancer POD (HEC [mg/m^3] or HED [mg/kg-day]) by the exposure estimate (mg/m^3 or mg/kg-day). Section 5.2 has additional information on the risk assessment approach for human health.
[6] It should be noted that, in some cases, baseline conditions may reflect certain mitigation measures, such as engineering controls, in instances where exposure estimates are based on monitoring data at facilities that have engineering controls in place.

7.1.1 Populations and Exposures EPA Assessed to Determine Unreasonable Risk to Human Health

EPA evaluated risk to workers (16+ years old), including ONUs, following intermediate and chronic exposures, as well as exposures to consumers, bystanders, and the general population of any life stage living near facilities releasing 1,3-butadiene into the environment via inhalation using reasonably available monitoring and modeling data for inhalation exposures, as applicable. EPA quantitatively assessed all manufacturing and processing COUs and the commercial use of laboratory chemicals, paints and coatings, and adhesives and sealants. All other commercial/consumer uses were qualitatively assessed.

As mentioned in Section 5.1, based on product searches and systematic review data, EPA determined that 1,3-butadiene, a monomer used in polymer-derived products such as synthetic rubbers, is stable in these products and not expected to degrade and expose workers or consumers to the 1,3-butadiene monomer. For the general population, EPA evaluated risk from chronic inhalation exposure from ambient air. No dermal or oral exposure is expected based on physical and chemical properties of 1,3-butadiene.

In developing the exposure and hazard assessments for 1,3-butadiene, EPA also analyzed reasonably available information to ascertain whether some human populations may have greater exposure and/or susceptibility than the general population to the hazard posed by 1,3-butadiene. For this 1,3-butadiene risk evaluation, the Agency accounted for the following PESS: females of reproductive age, males of reproductive age, pregnant females, infants, children and adolescents, people exposed to 1,3-butadiene in the workplace, populations who reside near 1,3-butadiene-releasing facilities, and racial/ethnic groups. The Agency also identified a list of specific PESS factors that contribute to a group having increased exposure or biological susceptibility, such as life stage in the basis for the intermediate/chronic POD, occupational exposures, nutrition, and lifestyle activities. EPA was able to incorporate considerations for multiple PESS factors into risk estimates, as presented in Section 5.3.5.

Descriptions of the data used for human health exposure and human health hazards are provided in Sections 5.1 and 5.2, respectively, in this risk evaluation. Uncertainties for overall exposures and hazards are presented in this risk evaluation and TSDs—including the *General Population Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025u), the *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q), and the *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)—and all are considered in this unreasonable risk determination.

7.1.2 Summary of Human Health Effects

EPA is determining that the unreasonable risk presented by 1,3-butadiene is due to:

- non-cancer effects and cancer in workers, including ONUs for one COU, from inhalation exposures.

EPA has robust overall confidence for the evidence integration, study/endpoint selection, exposure scenario applicability, dose-response, and PESS sensitivity of the conclusions. Similarly, EPA has robust confidence in the PODs for maternal/developmental toxicity from gestational exposure**,** including the POD based on reduced fetal body weight that was used for non-cancer risk estimates. Additionally, the POD selected (2.5 ppm [5,500 µg/m^3]) based on decreased fetal body weight) is protective of other non-cancer endpoints, particularly germ cell mutations (target organ: spermatids and spermatozoa) and anemia that yielded higher POD values. Candidate endpoints for an acute POD from repeat-dose studies were considered but have substantial uncertainties as to whether they are relevant to acute exposures; they were also found to be less protective than the intermediate/chronic POD. Therefore, a hazard value was *not* derived for risk estimation of acute exposures because it is unlikely any adverse effects will result following a single exposure at concentrations relevant to human exposures. Additionally, the POD for repeated exposures is expected to be protective of any potential acute hazard.

With respect to cancer risk, 1,3-butadiene is a potent multi-organ carcinogen in laboratory animals, notably inducing lymphomas in mice. EPA determined that 1,3-butadiene "is carcinogenic to humans," based primarily on robust human, animal, and mechanistic evidence for lymphohematopoietic and bladder cancers, though varying evidence for other cancer types was also identified. The Agency used an occupational epidemiological cohort with 50+ years of follow-up and subsequent exposure estimate updates to derive inhalation hazard values for leukemia and bladder cancer applicable to general population and occupational exposures. Due to an identified mutagenic mode of action for cancer, the Agency applied an ADAF to the IUR for leukemia and bladder cancer for the general population; that is, risk scenarios where children or adolescents aged under 16 years may be exposed. The IUR for general population risk estimation incorporating the ADAF is 0.00129 per ppm (5.83×10^{-6} per $\mu g/m^3$) and the chronic unit risk for occupational scenarios applied to adolescent and adult workers 16 years or older is 0.00644 per ppm (2.91×10^{-6} per $\mu g/m^3$).

The health risk estimates (MOEs) for workers (including ONUs), consumers, the general population, and PESS presented in Section 5.3.2 (workers), Section 5.3.3 (consumers), Section 5.3.4 (general population), and Section 5.3.5 (PESS) are not "bright-lines." EPA has discretion to consider other risk-related factors when concluding whether a COU significantly contributes to the unreasonable risk.

7.1.3 Basis for Unreasonable Risk to Workers

Based on the occupational risk estimates and related risk factors, EPA is determining that 11 COUs significantly contribute to the unreasonable risk of 1,3-butadiene due to non-cancer risks from intermediate and chronic inhalation exposure as well as cancer risks from inhalation exposures.

EPA was able to incorporate 1,3-butadiene inhalation monitoring data into its quantitative assessments for multiple COUs. For example, occupational risk estimates for nine COUs were derived using 5,500 full shift PBZ samples (between 2 and 1,952 samples per SEG) collected between 2010 and 2019 from 47 facilities that manufacture or process 1,3-butadiene. Because EPA's occupational risk assessment incorporates inhalation monitoring data, the Agency's risk estimates, including estimates at the high-end (95th percentile), reflect real working conditions based at 1,3-butadiene facilities. Therefore, high-end estimates are reasonably expected to occur and were considered for EPA's risk determination for COUs with monitoring data supporting the estimates. However, uncertainty in the estimates based off a statistical distribution of multiple single day measurements increases as the single day results are extrapolated to longer durations. Therefore, EPA's risk determination for 1,3-butadiene generally relies on high-end estimates to support its determination for workers for shorter-term inhalation exposures (*i.e.*, intermediate non-cancer risk covering average exposures over 1 month). This is because consistent high-end exposures are more likely to occur over shorter time periods, while central tendency estimates are used for longer term exposures (*i.e.*, several decades for chronic non-cancer and cancer). Additional discussion on the estimates used to inform EPA's determination is provided below.

Additionally, the ACC 1,3-Butadiene Toxic Substances Control Act (TSCA) Risk Evaluation Consortium (Consortium) provided information regarding the use of respirators (PPE). The information provided represents 100 percent of the 1,3-butadiene manufacturers and approximately 28 percent of the market associated with those who process 1,3-butadiene as a chemical reactant. The information indicates that respirators tend to be used for all tasks, with types varying depending on the task and air concentrations measured. Specifically for short-term exposures, the Consortium data indicate some type of respiratory protection is used for every task activity where 1,3-butadiene exposure might exceed the OSHA PEL occur. Based on this information, EPA believes that exposures that may occur and result in unreasonable risk in domestic manufacturing facilities are not necessarily being addressed through existing PPE practices. While there is evidence that PPE is worn, it is uncertain how consistently that is occurring at all facilities and for the entirety of the task/exposure duration. Therefore, EPA is not considering PPE use for the risk determination.

Workers

EPA determined that the following 11 COUs significantly contribute to the unreasonable non-cancer and cancer risk of 1,3-butadiene due to intermediate and chronic exposures:

- Manufacturing – domestic manufacturing;
- Manufacturing – importing;
- Processing as a reactant – intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing);
- Processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing);
- Processing – incorporation into formulation, mixture, or reaction product – plasticizer (asphalt paving, roofing, and coating materials manufacturing);
- Processing – incorporation into article – monomer (rubber product manufacturing);
- Processing – use-non-incorporative activities – fuel (petroleum refineries);
- Processing – repackaging – (wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing);
- Processing – recycling; and
- Disposal.

Risk was identified using high-end estimates for the intermediate duration (*e.g.*, 30 days). As stated previously, high-end estimates for workers are used in this risk determination for shorter term inhalation exposures (*i.e.*, intermediate non-cancer risk covering average exposures over 1 month) for COUs with inhalation data because it represents actual measured exposures and are more realistically consistent over shorter time periods. Industry provided a robust dataset for certain manufacturing and processing uses that allowed EPA to quantify risk estimates for not only the COU, but specific activities associated with that COU. The Agency identified unreasonable risk for Domestic manufacturing and Processing as a reactant – intermediate (in various industries) during the following activities or SEGs: Infrastructure/distribution operations – routine and nonroutine; Laboratory technician; Machinery & specialists; all Maintenance categories (including nonroutine and turnaround); Operations onsite (excluding nonroutine and turnaround); and Safety, health, and engineering. There were other SEGs for these two COUs where minimal risk was identified, including minimal risk to ONUs and minimal risk for any instrument and electrical SEGs. For the rest, the various datasets were used to inform estimates for two categories: Workers and ONUs. These are discussed in more detail below.

For two of the COUs with unreasonable risk (*i.e.*, Manufacturing – importing; and Processing – repackaging), EPA quantified risk for only two SEGs—Workers and ONUs. The inhalation exposure results for these COUs are based on 158 task-length PBZ samples associated with "unloading and transferring 1,3-butadiene to and from storage containers to process vessels." EPA assessed both a full shift assumption, which assumes that the estimated task-based exposure is occurring (MOE = 4.4 and 1.1×10^{-3}). However, particularly for repackaging facilities, the task-length assumption may underestimate exposures, since it assumes the worker will have no additional exposure outside of the length of the task in a workplace known to have 1,3-butadiene. Additionally, the full shift and task-length assumptions together estimate the range of exposures that a worker may experience during these activities at a repackaging facility. There are uncertainties regarding the full shift exposures occurring during the import of 1,3-butadiene. Therefore, due to EPA's moderate to robust confidence in the risk estimates relative to benchmarks for Import and Repackaging, EPA is determining that these COUs contribute to the unreasonable risk to workers for both cancer and non-cancer using the full shift assumption and for non-cancer using the task-based assumption when PPE is not worn. The Repackaging COU is based on the task-based and full shift assumptions, while Import is based on the task-based assumption. See Section 5.3.2 for more information.

EPA is also determining that Disposal significantly contributes to the unreasonable risk of 1,3-butadiene for both cancer and non-cancer. This COU captures waste handling, treatment, and disposal, which includes both 1,3-butadiene that is recycled and often combined with crude streams for energy recovery as well as 1,3-butadiene produced as a byproduct or impurity in an industrial setting and subsequently burned. The inhalation exposure results were based on 10 task-length PBZ samples labeled as "handling, transporting and disposing of waste containing 1,3-butadiene," and similar to the Importing and Repackaging COUs, EPA quantified estimates using both the full shift and task-based assumption. The data submitted informing these estimates indicate that the task is a routine occurrence—meaning that it generally occurs once per day at the manufacturing or processing site. However, it is likely that a recycling or waste handling facility may perform these activities more frequently than once daily. Risk was indicated for workers at both the central tendency and the high-end for intermediate and chronic durations based on the full shift assumption (*i.e.*, MOEs ranges from 3.9–23 and the cancer risk was as high as 1.2×10^{-3}). There are uncertainties due to the high number of samples below the LOD (*i.e.*, there was only 1 detect out of 10 samples). However, EPA believes these data points to be the best representation reasonably available of 1,3-butadiene exposure for disposal activities and, though EPA's overall confidence in the risk estimates for this OES is slight to moderate, this is due to the number of non-detects (9 of 10 samples) and not the lack of confidence in the individual dataset.

EPA's determination of unreasonable risk from Processing as a reactant – monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing) is for both cancer and non-cancer risks to workers. That is, the central tendency MOE for chronic non-cancer was 14, the high-end MOE for intermediate non-cancer was 0.30, and the additional cancer risk was 2.9×10^{-4}. Minimal risk to ONUs was identified for this COU. For the three COUs associated with the plastics and rubber compounding and converting OES—Processing – incorporation into formulation, mixture, or reaction product – monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing); Processing – incorporation into formulation, mixture, or reaction product – plasticizer (asphalt paving, roofing, and coating materials manufacturing); and Processing – incorporation into article – monomer (rubber product manufacturing)—EPA's determination of unreasonable risk is due to intermediate inhalation exposure informed by 53 8-hour worker sample relevant to plastics and rubber compounding, 50 8-hour samples relevant to plastics and rubber converting, and 44 12-hour samples used for both.

There were six other COUs for which EPA conducted a quantitative analysis but did not identify unreasonable risk to workers or ONUs: Processing – incorporation into formulation, mixture, or reaction product – intermediate (petrochemical manufacturing); Processing – incorporation into formulation, mixture, or reaction product – other (oil and gas drilling, extraction, and support activities); Industrial and commercial use of adhesives and sealants; Commercial use of paints and coatings; and Commercial use of laboratory chemicals. MOEs were well above the benchmark for the Industrial and commercial use of adhesives and sealants as well as the Commercial use of paints and coatings COU, and no cancer risk was indicated for these uses. Due to the use of analogous data for the four COUs under Processing – incorporation into formulation, mixture, or reaction product, EPA used the central tendency estimate to support its determination of no unreasonable risk (which did not indicate risk for non-cancer or cancer). This is because the high-end estimates are not reasonably expected since a smaller concentration of 1,3-butadiene would be going toward these scenarios as opposed to processing as a reactant and manufacturing. Similarly, for the commercial use of laboratory chemicals, high-end estimates are overly conservative and may portray exposure to potentially high-exposure tasks that are exclusive to laboratory technicians in a manufacturing and process facility but that would not occur in a commercial setting. Therefore, central tendency estimates were also used to inform EPA's determination of no unreasonable risk for the Use of laboratory chemicals.

ONUs

EPA is determining that one COU significantly contributes to the unreasonable non-cancer and cancer risk of 1,3-butadiene to ONUs due to intermediate and chronic inhalation exposure:

- Processing – repackaging.

Risk for ONUs was indicated for three COUs: Importing, Repackaging, and Disposal. For these COUs, there were no ONU exposure data reasonably available. Therefore, EPA assumed that ONU exposure is equal to the central tendency worker exposure, resulting in only one value per exposure duration and endpoint (rather than a separate central tendency and high-end value). As previously mentioned, for all three of these COUs, EPA quantified risk for a (1) full shift assumption, which assumes that the estimated task-based exposure is occuring for an entire 8-hour shift; and (2) task-length assumption, which assumes that the estimated task-based exposure takes place for the duration of the task and with no exposure for the remainder of the 8-hour shift. For all three COUs, the unreasonable risk to ONUs is found only for the full shift assumption. As discuss previously, the full shift assumption may be overly conservative for the Import COU. For the other two COUs, there is uncertainty on whether ONUs will be exposed to a full 8-hours rather than a task-length (*e.g.*, 100 minutes) assumption. However, it is reasonable that the full shift exposure could occur, especially at repackaging or disposal facilities. Therefore, EPA is determining that the Repackaging COU significantly contributes to the unreasonable risk for ONUs based on the full shift assumption from non-cancer for intermediate exposures (MOE of 11). EPA is not determining that the Disposal COU significantly contributes to the risk to ONUs due to EPA having less confidence in the disposal dataset (*i.e.*, slight to moderate) and its use to then inform a full shift assumption for an ONU.

7.1.4 Basis for No Unreasonable Risk to Consumers

Based on the assessment of consumer risk and related risk factors, EPA is determining that no consumer COUs significantly contribute to the unreasonable risk of 1,3-butadiene. The Agency qualitatively assessed the possibility of 1,3-butadiene monomer exposure from polymer-derived consumer products in Section 5.1.2 and concluded that there is limited potential for exposure to the 1,3-butadiene monomer from consumer use COUs. In addition, EPA conducted a sensitivity analysis for the risk characterization of consumer COUs using the CEM Version 3.2 (U.S. EPA, 2023) to model exposure and dose across a range of 1,3-butadiene weight fractions and surface areas of toys (see Section 5.3.3). The Agency did not find appreciable risk to consumers even when exaggerated weight fractions were input into the model. Thus, EPA is determining that the consumer COUs do not significantly contribute to unreasonable risk from 1,3-butadiene.

7.1.5 Basis for No Unreasonable Risk to the General Population

Based on the risk estimates calculated using releases from manufacturing, processing, and commercial uses of 1,3-butadiene and related risk factors, EPA determined that general population pathways, including those for fenceline communities, do not significantly contribute to unreasonable risk from 1,3-butadiene. This final determination regarding the general population, particularly from exposures of 1,3-butadiene due to the ambient air pathway, considers the updates made to the analysis from the draft to this final risk evaluation, including an updated IUR and use of NEI data in the HEM analysis.

The Agency identified the ambient air pathway to be the predominant human exposure pathway of concern for risk to the general population, including fenceline communities from 1,3-butadiene. Other exposures to 1,3-butadiene from the land, surface water, sediment, and drinking water pathways are not expected and therefore do not significantly contribute to unreasonable risk of 1,3-butadiene, due in part to the chemical properties of 1,3-butadiene (*e.g.*, high volatility and reactivity, low sorption to organic material, low water solubility, low estimated K_{OC} value) and low potential for exposure. For further information, see Section 4.2.

EPA typically considers an increased cancer risk above benchmarks ranging from 1 in 1,000,000 to 1 in 10,000 (*i.e.*, 1×10^{-6} to 1×10^{-4}) with a focus on areas with increased chronic inhalation cancer risk levels over 1 in 1,000,000. However, as previously discussed for other populations and pathways, the estimates are not treated as a bright-line and other risk-based factors are considered (*e.g.*, the magnitude of the chronic inhalation cancer risk, maximum risk, the size of the population at increased risk, confidence in the hazard and exposure characterization, duration, uncertainty, populations exposed) for purposes of making an unreasonable risk determination. EPA's analytical framework under TSCA is similar to other EPA programs (*e.g.*, the Clean Air Act [CAA], Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA]), which include consideration of other relevant risk-related information as required by TSCA. EPA also considers PESS.

The Agency conducted a quantitative exposure assessment for the air pathway using a tiered approach to evaluate non-cancer and cancer risks for the general population. For tier I and II analyses, EPA used the IIOAC Model with TRI data and HEM with both TRI and estimated releases for generic facilities/sites to assess ambient air inhalation risks to the general population. Based on tier I and II aggregate non-cancer risk estimates, risks were not expected for the general population; therefore, EPA is determining that non-cancer risk from ambient air does not significantly contribute to the unreasonable risk to the general population from exposure to 1,3-butadiene for any COU. Because tier I and II results indicate cancer risk estimates at or above 1 in a million for COUs, EPA conducted a more refined tier III analysis of ambient air concentrations and inhalation cancer risk estimates. Based on the tier III census block analysis, cancer risk estimates for ambient air exposures indicated an increased cancer risk for five COUs within but not above 1 in 1,000,000 to 1 in 10,000 (*i.e.*, 1×10^{-6} to 1×10^{-4}). Elevated cancer risks are concentrated in areas along the Gulf Coast region from Texas to Louisiana, primarily between Houston and Baton Rouge. Considering the relatively low maximum risk and the small number of persons exposed resulting in low cancer incidence, EPA determined that 1,3-butadiene exposures to the general population do not significantly contribute to unreasonable risk to the general population due to cancer risk from inhalation exposure under these COUs.

Based on EPA's tier III census block analysis, risk estimates were at or exceeded 1 in 1,000,000 for five COUs:

- Domestic manufacturing;
- Processing as a reactant – other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics;

- 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;
- Manufacturing – import; and
- Processing – repackaging.

For the tier III analysis, EPA used HEM with NEI 2017 and 2020 data to refine ambient air concentrations and inhalation cancer risk estimates at the centroid of census blocks within 50 km of 55 of the highest releasing facilities. EPA then aggregated and summarized cancer risk estimates from HEM to characterize exposures and associate risks by COUs/OESs. This introduces some uncertainty within the aggregated results because a single facility may have multiple processes that are categorized into different COUs/OESs but aggregated together under a single COU/OES based on primary NAICS for the facility. The range of cancer risks across all NEI facilities and COU/OES was 3.1×10^{-11} to 3.4×10^{-5}. The maximum facility cancer risk estimate (3.4×10^{-5}) occurs under the Plastics and rubber polymerization COU/OES and represents the highest cancer risk estimate modeled at a receptor (*e.g.*, census block centroid receptor) out of all the receptors modeled within 50 km from that facility. Altogether, 30 out of the 55 NEI facilities evaluated resulted in cancer risk estimates at or above 1 in 1,000,000.

Based on the multi-facility aggregate census block cancer risk, a total population of 64,384 people within 55 km from all 55 NEI facilities have cancer risk estimates at or above 1 in 1,000,000, and a population of 372 people have cancer risk estimates at or greater than 1 in 100,000. A total of 232 of those 372 people with cancer risk estimates exceeding 1 in 100,000 are accounted for by census block ID 625001001 in Norco, Louisiana, with 10 NEI facilities releasing 1,3-butadiene located within 50 km. Although 10 facilities contribute to this aggregate cancer risk estimate at this census block, a single facility, categorized under the manufacture-repackaging COU/OES, contributes about 97 percent of the total aggregated cancer risk estimate with a facility cancer risk estimate of 2.8×10^{-5} (2.8 in 100,000).

Census block ID 114022071 in Beaumont, Texas, with a population of seven people had the highest aggregate cancer risk estimate of 3.4×10^{-5} (3.4 in 100,000). Twenty facilities contribute to the aggregate cancer risk estimate at this census block, with a single facility accounting for nearly 100 percent of the total aggregated cancer risk estimate with a facility cancer risk estimate of 3.4×10^{-5} (3.4 in 100,000). The closest of the 20 facilities is located within 500 m of this census block and is categorized under the Processing – plastics and rubber compounding COU/OES.

Of the 1,056,352 people living within 5 km of the NEI facilities, 60,786 people (≈6% of the exposed population) live in a census block that resulted in a cancer risk estimate at or above 1 in 1,000,000. At that location, the number of persons exposed to elevated risk is low and only represents a small portion of the overall population potentially exposed to 1,3-butadiene from these COUs. As explained in Section 5.3.5, this cancer risk from exposure to 1,3-butadiene released from facilities associated with COUs would result in 0.06 excess cancer cases in this population or 9×10^{-4} (0.0009) additional cases per year when assuming a 70-year lifetime for this population. The small number of persons exposed to increased risk (on the lower end of the benchmark range) and the low predicted cancer incidence both suggest that these pathways do not significantly contribute to unreasonable risk.

EPA further considered the conservative assumptions incorporated into this assessment, some of which may bias toward higher exposure and risk. The Agency has robust confidence in underlying release information used to estimate exposures, as well as in the use of peer-reviewed models to assess general population exposure—including those living near releasing facilities and PESS as well as the human, animal, and mechanistic evidence associating leukemia and other lymphohematopoietic cancers with 1,3-butadiene exposure. Additionally, the use of HEM allowed for the characterization of populations living near facilities. However, potential conservative assumptions and uncertainties considered in the risk characterization exist in EPA's determination of no unreasonable risk to the general population. The modeled scenarios informing the risk estimates are based on modeled ambient air concentrations 24 hours a day, 365 days a year, over a lifetime (*i.e.*, 70 years). Although EPA has confidence in these estimates representing actual populations (based on census data), there is uncertainty in the assumptions of continuous 1,3-butadiene ambient air to an individual all day, all year-round, for their entire lifetime, including the extent to which people spend a lifetime living that close to the specific facilities where risks are highest.

The health-protective assumption of continuous lifetime exposure is likely to bias exposure (and risk) high. In addition, risk estimates based on census block centroids may underestimate or overestimate risk to individuals with residences not at the centroid. EPA also acknowledges the limitation of the use of TRI and NEI release data since release data are reported as a total release for the respective reporting year. As a result, the total releases are annually- and daily-averaged to estimate modeled concentrations. However, the use of annually- and daily-averaged concentrations is appropriate for chronic exposure assessments and risk estimates over a lifetime. Despite these uncertainties, EPA has overall robust confidence in the general population risk characterization. Additional information on EPA's overall confidence and uncertainties for the general population risk assessment can be found in Section 5.3.7.3. Taken together, due to these potential biases towards high exposures, combined with relatively low maximum cancer risks, low cancer incidence, and an exposed small population, EPA is determining that these pathways do not significantly contribute to unreasonable risk of 1,3-butadiene.

7.2 Unreasonable Risk to the Environment

Based on the risk evaluation for 1,3-butadiene—including the populations and exposures assessed, the environmental effects, and consideration of uncertainties—EPA did not identify unreasonable risk of injury to the environment for 1,3-butadiene.

Given the fate properties of 1,3-butadiene, an in-depth analysis of releases to water or land and associated exposures from those releases was not conducted. The environmental risk characterization for 1,3-butadiene involved a review of release and monitoring data that demonstrated limited release and that 1,3-butadiene was not detected in water. In addition, EPA does not expect that 1,3-butadiene will persist in surface water or groundwater, adsorb to soil or sediment, or persist on land, due to its physical and chemical properties (*i.e.*, gas form under ambient conditions, high volatility and reactivity, low sorption potential). Extensive ambient air monitoring data are available for 1,3-butadiene, which shows that 1,3-butadiene is prevalent in ambient air and confirms that air is a major 1,3-butadiene exposure pathway. Although these data demonstrate 1,3-butadiene concentrations in ambient air, the source is unknown. Concentrations of 1,3-butadiene in ambient air are likely from a combination of COUs and other sources (*e.g.*, forest fires, mobile exhaust, etc.).

7.2.1 Basis for No Unreasonable Risk to the Environment

Although 1,3-butadiene may be released to water, land, and air, 1,3-butadiene concentrations were not modeled for the surface water and land pathways because 1,3-butadiene is primarily released as a gas to air. It is not expected to persist in soil and water based on physical and chemical properties and environmental fate and transport characteristics. EPA found no unreasonable risk to aquatic organisms or terrestrial organisms. Although exposure of 1,3-butadiene to terrestrial organisms via ambient air is the primary pathway of concern, EPA's screening analysis showed that minimal risk was expected; the most sensitive toxicity endpoint for terrestrial exposure to 1,3-butadiene via inhalation was 20 ppm (44,240 µg/m^3), and the highest ambient air concentration modeled (383.4 µg/m^3) and monitored (122.8 mg/m^3). Therefore, given that modeled and measured 1,3-butadiene concentrations in ambient air are two orders of magnitude lower than the most sensitive toxicity endpoint available for vertebrates, there is no expected risk to terrestrial organisms exposed to 1,3-butadiene from COUs. EPA determined that 1,3-butadiene does not present an unreasonable risk of injury to the environment for any pathway.

7.3 Supporting Basis for the Unreasonable Risk Determination

Table 7-1 summarizes the basis for this unreasonable risk determination of injury to human health for workers and ONUs presented in this 1,3-butadiene risk evaluation. In Table 7-1, bold and gray-shaded text indicates that an MOE is below the MOE benchmark value of 30 or above a cancer risk of 1×10^{-4}. Table 7-1 also identifies both the duration of exposure (*i.e.*, intermediate, chronic duration) and the exposure route to the population. As explained in Section 7.2, for this unreasonable risk determination, EPA considered the effects of 1,3-butadiene to human health and the environment, including PESS, as well as a range of risk estimates as appropriate, risk-related factors, and the confidence in the analysis. See Sections 5.3 and 6.3 for a summary of risk estimates.

Table 7-1. Supporting Basis for the Unreasonable Risk Determination for Human Health (Occupational COUs, Inhalation Exposure)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Manufacture/ Domestic manufacturing	Domestic manufacture	Infrastructure/ Distribution Operations [a]	Inhalation 8-hour TWA	Central Tendency	906	970	4.1E−06	9,061 (APF 10)	9,701 (APF 10)	4.1E−07 (APF 10)
				High-End	**11**	**12**	**4.2E−04**	114 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)
		Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 8-hour TWA	Central Tendency	60	725	5.4E−06	596 (APF 10)	7,251 (APF 10)	5.4E−07 (APF 10)
				High-End	**28**	342	1.5E−05	281 (APF 10)	3,422 (APF 10)	1.5E−06 (APF 10)
		Instrument and Electrical [b]	Inhalation 8-hour TWA	Central Tendency	1.9E04	2.1E04	1.9E−07	1.9E05 (APF 10)	2.1E05 (APF 10)	1.9E−08 (APF 10)
				High-End	49	53	9.6E−05	494 (APF 10)	528 (APF 10)	9.6E−06 (APF 10)
		Instrument and Electrical – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	165	2,002	2.0E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.0E−07 (APF 10)
				High-End	165	2,002	2.5E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.5E−07 (APF 10)
		Instrument and Electrical – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	463	5,636	7.0E−07	4,632 (APF 10)	5.6E04 (APF 10)	7.0E−08 (APF 10)
				High-End	57	689	7.4E−06	567 (APF 10)	6,893 (APF 10)	7.4E−07 (APF 10)
		Laboratory Technician [b]	Inhalation 8-hour TWA	Central Tendency	735	787	5.0E−06	7,351 (APF 10)	7,870 (APF 10)	5.0E−07 (APF 10)
				High-End	**21**	**22**	**2.3E−04**	210 (APF 10)	225 (APF 10)	2.3E−05 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Manufacture/ Domestic manufacturing *(continued)*	Domestic manufacture *(continued)*	Machinery and Specialists [b]	Inhalation 8-hour TWA	Central Tendency	5,468	5855	6.7E−07	5.5E04 (APF 10)	5.9E04 (APF 10)	6.7E−08 (APF 10)
				High-End	**20**	**22**	**2.4E−04**	202 (APF 10)	217 (APF 10)	2.4E−05 (APF 10)
		Machinery and Specialists – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	984	1.2E04	3.3E−07	9,844 (APF 10)	1.2E05 (APF 10)	3.3E−08 (APF 10)
				High-End	656	7,984	6.4E−07	6,563 (APF 10)	8.0E04 (APF 10)	6.4E−08 (APF 10)
		Maintenance [b]	Inhalation 8-hour TWA	Central Tendency	333	357	1.1E−05	3,331 (APF 10)	3,566 (APF 10)	1.1E−06 (APF 10)
				High-End	**7.1**	**7.6**	**6.7E−04**	71 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)
		Maintenance – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	65	787	5.0E−06	647 (APF 10)	7,867 (APF 10)	5.0E−07 (APF 10)
				High-End	36	433	1.2E−05	356 (APF 10)	4,334 (APF 10)	1.2E−06 (APF 10)
		Maintenance – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	466	5,667	7.0E−07	4,658 (APF 10)	5.7E04 (APF 10)	7.0E−08 (APF 10)
				High-End	**1.5**	**19**	**2.7E−04**	39 (APF 25)	188 (APF 10)	2.7E−05 (APF 10)
		Operations Onsite [b]	Inhalation 8-hour TWA	Central Tendency	1.4E04	1.5E04	2.7E−07	1.4E05 (APF 10)	1.5E05 (APF 10)	2.7E−08 (APF 10)
				High-End	38	40	**1.3E−04**	376 (APF 10)	403 (APF 10)	1.3E−05 (APF 10)
		Operations Onsite – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	689	8,384	4.7E−07	6,891 (APF 10)	8.4E04 (APF 10)	4.7E−08 (APF 10)
				High-End	165	2,002	2.5E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.5E−07 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Manufacture/ Domestic manufacturing *(continued)*	Domestic manufacture *(continued)*	Operations Onsite – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	3.9E05	4.8E06	8.3E−10	3.9E06 (APF 10)	4.8E07 (APF 10)	8.3E−11 (APF 10)
				High-End	113	1,377	3.7E−06	1,132 (APF 10)	1.4E04 (APF 10)	3.7E−07 (APF 10)
		Safety Health and Engineering [b]	Inhalation 8-hour TWA	Central Tendency	303	324	1.2E−05	3,027 (APF 10)	3,241 (APF 10)	1.2E−06 (APF 10)
				High-End	**10**	**11**	**4.6E−04**	103 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)
		ONU [c]	Inhalation 8-hour TWA	Central Tendency	866	928	4.3E−06	–	–	–
				High-End	245	263	1.9E−05	–	–	–
		Infrastructure/ Distribution Operations [a]	Inhalation 12-hour TWA	Central Tendency	604	968	4.1E−06	6,041 (APF 10)	9,682 (APF 10)	4.1E−07 (APF 10)
				High-End	**7.6**	**12**	**4.2E−04**	76 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)
		Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 12-hour TWA	Central Tendency	40	483	8.2E−06	397 (APF 10)	4,834 (APF 10)	8.2E−07 (APF 10)
				High-End	**19**	228	2.2E−05	188 (APF 10)	2,281 (APF 10)	2.2E−06 (APF 10)
		Instrument and Electrical [b]	Inhalation 12-hour TWA	Central Tendency	1.3E04	2.1E04	1.9E−07	1.3E05 (APF 10)	2.1E05 (APF 10)	1.9E−08 (APF 10)
				High-End	33	53	9.7E−05	329 (APF 10)	527 (APF 10)	9.7E−06 (APF 10)
		Instrument and Electrical – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	110	1,335	3.0E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.0E−07 (APF 10)
				High-End	110	1,335	3.8E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.8E−07 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Manufacture/ Domestic manufacturing *(continued)*	Domestic manufacture *(continued)*	Instrument and Electrical – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	309	3,757	1.0E−06	3,088 (APF 10)	3.8E04 (APF 10)	1.0E−07 (APF 10)
				High-End	38	460	1.1E−05	378 (APF 10)	4,595 (APF 10)	1.1E−06 (APF 10)
		Laboratory Technician [b]	Inhalation 12-hour TWA	Central Tendency	490	785	5.0E−06	4,900 (APF 10)	7,854 (APF 10)	5.0E−07 (APF 10)
				High-End	**14**	**22**	**2.3E−04**	140 (APF 10)	224 (APF 10)	2.3E−05 (APF 10)
		Machinery and Specialists [b]	Inhalation 12-hour TWA	Central Tendency	3,646	5,843	6.8E−07	3.6E04 (APF 10)	5.8E04 (APF 10)	6.8E−08 (APF 10)
				High-End	**13**	**22**	**2.4E−04**	135 (APF 10)	216 (APF 10)	2.4E−05 (APF 10)
		Machinery and Specialists – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	656	7,984	4.9E−07	6,563 (APF 10)	8.0E04 (APF 10)	4.9E−08 (APF 10)
				High-End	438	5,323	9.6E−07	4,375 (APF 10)	5.3E04 (APF 10)	9.6E−08 (APF 10)
		Maintenance [b]	Inhalation 12-hour TWA	Central Tendency	222	356	1.1E−05	2,220 (APF 10)	3,559 (APF 10)	1.1E−06 (APF 10)
				High-End	**4.8**	**7.6**	**6.7E−04**	48 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)
		Maintenance – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	43	524	7.5E−06	431 (APF 10)	5,245 (APF 10)	7.5E−07 (APF 10)
				High-End	**24**	289	1.8E−05	237 (APF 10)	2,889 (APF 10)	1.8E−06 (APF 10)
		Maintenance – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	311	3,778	1.0E−06	3,105 (APF 10)	3.8E04 (APF 10)	1.0E−07 (APF 10)
				High-End	**1.0**	**13**	**4.1E−04**	51 (APF 50)	125 (APF 10)	4.1E−05 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Manufacture/ Domestic manufacturing *(continued)*	Domestic manufacture *(continued)*	Operations Onsite [b]	Inhalation 12-hour TWA	Central Tendency	9,241	1.5E04	2.7E−07	9.2E04 (APF 10)	1.5E05 (APF 10)	2.7E−08 (APF 10)
				High-End	**25**	40	**1.3E−04**	251 (APF 10)	402 (APF 10)	1.3E−05 (APF 10)
		Operations Onsite – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	459	5,589	7.1E−07	4,594 (APF 10)	5.6E04 (APF 10)	7.1E−08 (APF 10)
				High-End	110	1,335	3.8E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.8E−07 (APF 10)
		Operations Onsite – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	2.6E05	3.2E06	1.2E−09	2.6E06 (APF 10)	3.2E07 (APF 10)	1.2E−10 (APF 10)
				High-End	75	918	5.5E−06	755 (APF 10)	9,181 (APF 10)	5.5E−07 (APF 10)
		Safety Health and Engineering [b]	Inhalation 12-hour TWA	Central Tendency	202	323	1.2E−05	2,018 (APF 10)	3,234 (APF 10)	1.2E−06 (APF 10)
				High-End	**6.9**	**11**	**4.6E−04**	69 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)
		ONU [c]	Inhalation 12-hour TWA	Central Tendency	578	926	4.3E−06	–	–	–
				High-End	164	262	1.9E−05	–	–	–
Manufacturing/ Importing Processing/ Repackaging	Importing Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing	Worker [a] (full length)	Inhalation 8-hour TWA	Central Tendency	**11**	**12**	**3.3E−04**	111 (APF 10)	119 (APF 10)	3.3E−05 (APF 10)
				High-End	**0.23**	**0.24**	**2.1E−02**	**11** (APF 50)	**12** (APF 50)	**4.2E−04** (APF 50)
		ONU [c] (full length)	Inhalation 8-hour TWA	Central Tendency	**11**	**12**	**3.3E−04**	–	–	–
				High-End	**11**	**12**	**4.3E−04**	–	–	–

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Manufacturing/ Importing Processing/ Repackaging *(continued)*	Importing Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing *(continued)*	Worker [a] (task-length)	Inhalation 8-hour TWA	Central Tendency	196	210	1.9E−05	1,963 (APF 10)	2,102 (APF 10)	1.9E−06 (APF 10)
				High-End	**4.4**	**4.7**	**1.1E−03**	44 (APF 10)	47 (APF 10)	4.3E−05 (APF 25)
		ONU [c] (task-length)	Inhalation 8-hour TWA	Central Tendency	196	210	1.9E−05	–	–	–
				High-End	196	210	2.4E−05	–	–	–
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling	Infrastructure/ Distribution Operations [a]	Inhalation 8-hour TWA	Central Tendency	906	970	4.1E−06	9,061 (APF 10)	9,701 (APF 10)	4.1E−07 (APF 10)
				High-End	**11**	**12**	**4.2E−04**	114 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)
		Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 8-hour TWA	Central Tendency	60	725	5.4E−06	596 (APF 10)	7,251 (APF 10)	5.4E−07 (APF 10)
				High-End	**28**	342	1.5E−05	281 (APF 10)	3,422 (APF 10)	1.5E−06 (APF 10)
		Instrument and Electrical [b]	Inhalation 8-hour TWA	Central Tendency	1.9E04	2.1E04	1.9E−07	1.9E05 (APF 10)	2.1E05 (APF 10)	1.9E−08 (APF 10)
				High-End	49	53	9.6E−05	494 (APF 10)	528 (APF 10)	9.6E−06 (APF 10)
		Instrument and Electrical – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	165	2,002	2.0E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.0E−07 (APF 10)
				High-End	165	2,002	2.5E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.5E−07 (APF 10)
		Instrument and Electrical – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	463	5,636	7.0E−07	4,632 (APF 10)	5.6E04 (APF 10)	7.0E−08 (APF 10)
				High-End	57	689	7.4E−06	567 (APF 10)	6,893 (APF 10)	7.4E−07 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling *(continued)*	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling *(continued)*	Laboratory Technician [b]	Inhalation 8-hour TWA	Central Tendency	735	787	5.0E−06	7,351 (APF 10)	7,870 (APF 10)	5.0E−07 (APF 10)
				High-End	**21**	**22**	**2.3E−04**	210 (APF 10)	225 (APF 10)	2.3E−05 (APF 10)
		Machinery and Specialists [b]	Inhalation 8-hour TWA	Central Tendency	5,468	5,855	6.7E−07	5.5E04 (APF 10)	5.9E04 (APF 10)	6.7E−08 (APF 10)
				High-End	**20**	**22**	**2.4E−04**	202 (APF 10)	217 (APF 10)	2.4E−05 (APF 10)
		Machinery and Specialists – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	984	1.2E04	3.3E−07	9,844 (APF 10)	1.2E05 (APF 10)	3.3E−08 (APF 10)
				High-End	656	7,984	6.4E−07	6,563 (APF 10)	8.0E04 (APF 10)	6.4E−08 (APF 10)
		Maintenance [b]	Inhalation 8-hour TWA	Central Tendency	333	357	1.1E−05	3,331 (APF 10)	3,566 (APF 10)	1.1E−06 (APF 10)
				High-End	**7.1**	**7.6**	**6.7E−04**	71 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)
		Maintenance – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	65	787	5.0E−06	647 (APF 10)	7,867 (APF 10)	5.0E−07 (APF 10)
				High-End	36	433	1.2E−05	356 (APF 10)	4,334 (APF 10)	1.2E−06 (APF 10)
		Maintenance – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	466	5,667	7.0E−07	4,658 (APF 10)	5.7E04 (APF 10)	7.0E−08 (APF 10)
				High-End	**1.5**	**19**	**2.7E−04**	39 (APF 25)	188 (APF 10)	2.7E−05 (APF 10)
		Operations Onsite [b]	Inhalation 8-hour TWA	Central Tendency	1.4E04	1.5E04	2.7E−07	1.4E05 (APF 10)	1.5E05 (APF 10)	2.7E−08 (APF 10)
				High-End	38	40	**1.3E−04**	376 (APF 10)	403 (APF 10)	1.3E−05 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling *(continued)*	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling *(continued)*	Operations Onsite – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	689	8,384	4.7E−07	6,891 (APF 10)	8.4E04 (APF 10)	4.7E−08 (APF 10)
				High-End	165	2,002	2.5E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.5E−07 (APF 10)
		Operations Onsite – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	3.9E05	4.8E06	8.3E−10	3.9E06 (APF 10)	4.8E07 (APF 10)	8.3E−11 (APF 10)
				High-End	113	1,377	3.7E−06	1,132 (APF 10)	1.4E04 (APF 10)	3.7E−07 (APF 10)
		Safety Health and Engineering [b]	Inhalation 8-hour TWA	Central Tendency	303	324	1.2E−05	3,027 (APF 10)	3,241 (APF 10)	1.2E−06 (APF 10)
				High-End	10	11	4.6E−04	103 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)
		ONU [c]	Inhalation 8-hour TWA	Central Tendency	866	928	4.3E−06	8,663 (APF 10)	9,275 (APF 10)	4.3E−07 (APF 10)
				High-End	245	263	1.9E−05	2,453 (APF 10)	2,626 (APF 10)	1.9E−06 (APF 10)
		Infrastructure/ Distribution Operations [a]	Inhalation 12-hour TWA	Central Tendency	604	968	4.1E−06	6,041 (APF 10)	9,682 (APF 10)	4.1E−07 (APF 10)
				High-End	**7.6**	**12**	**4.2E−04**	76 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)
		Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 12-hour TWA	Central Tendency	40	483	8.2E−06	397 (APF 10)	4,834 (APF 10)	8.2E−07 (APF 10)
				High-End	19	228	2.2E−05	188 (APF 10)	2,281 (APF 10)	2.2E−06 (APF 10)
		Instrument and Electrical [b]	Inhalation 12-hour TWA	Central Tendency	1.3E04	2.1E04	1.9E−07	1.3E05 (APF 10)	2.1E05 (APF 10)	1.9E−08 (APF 10)
				High-End	33	53	9.7E−05	329 (APF 10)	527 (APF 10)	9.7E−06 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling *(continued)*	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling *(continued)*	Instrument and Electrical – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	110	1,335	3.0E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.0E−07 (APF 10)
				High-End	110	1,335	3.8E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.8E−07 (APF 10)
		Instrument and Electrical – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	309	3,757	1.0E−06	3,088 (APF 10)	3.8E04 (APF 10)	1.0E−07 (APF 10)
				High-End	38	460	1.1E−05	378 (APF 10)	4,595 (APF 10)	1.1E−06 (APF 10)
		Laboratory Technician [b]	Inhalation 12-hour TWA	Central Tendency	490	785	5.0E−06	4,900 (APF 10)	7,854 (APF 10)	5.0E−07 (APF 10)
				High-End	**14**	**22**	**2.3E−04**	140 (APF 10)	224 (APF 10)	2.3E−05 (APF 10)
		Machinery and Specialists [b]	Inhalation 12-hour TWA	Central Tendency	3,646	5,843	6.8E−07	3.6E04 (APF 10)	5.8E04 (APF 10)	6.8E−08 (APF 10)
				High-End	**13**	**22**	**2.4E−04**	135 (APF 10)	216 (APF 10)	2.4E−05 (APF 10)
		Machinery and Specialists – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	656	7,984	4.9E−07	6,563 (APF 10)	8.0E04 (APF 10)	4.9E−08 (APF 10)
				High-End	438	5,323	9.6E−07	4,375 (APF 10)	5.3E04 (APF 10)	9.6E−08 (APF 10)
		Maintenance [b]	Inhalation 12-hour TWA	Central Tendency	222	356	1.1E−05	2,220 (APF 10)	3,559 (APF 10)	1.1E−06 (APF 10)
				High-End	**4.8**	**7.6**	**6.7E−04**	48 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)
		Maintenance – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	43	524	7.5E−06	431 (APF 10)	5,245 (APF 10)	7.5E−07 (APF 10)
				High-End	**24**	289	1.8E−05	237 (APF 10)	2,889 (APF 10)	1.8E−06 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing as a reactant Processing/ Use-non-incorporative activities Processing/ Recycling *(continued)*	Intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing) Fuel (petroleum refineries) Recycling *(continued)*	Maintenance – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	311	3,778	1.0E−06	3,105 (APF 10)	3.8E04 (APF 10)	1.0E−07 (APF 10)
				High-End	**1.0**	**13**	**4.1E−04**	51 (APF 50)	125 (APF 10)	4.1E−05 (APF 10)
		Operations Onsite [b]	Inhalation 12-hour TWA	Central Tendency	9,241	1.5E04	2.7E−07	9.2E04 (APF 10)	1.5E05 (APF 10)	2.7E−08 (APF 10)
				High-End	**25**	40	**1.3E−04**	251 (APF 10)	402 (APF 10)	1.3E−05 (APF 10)
		Operations Onsite – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	459	5,589	7.1E−07	4,594 (APF 10)	5.6E04 (APF 10)	7.1E−08 (APF 10)
				High-End	110	1,335	3.8E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.8E−07 (APF 10)
		Operations Onsite – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	2.6E05	3.2E06	1.2E−09	2.6E06 (APF 10)	3.2E07 (APF 10)	1.2E−10 (APF 10)
				High-End	75	918	5.5E−06	755 (APF 10)	9,181 (APF 10)	5.5E−07 (APF 10)
		Safety Health and Engineering [b]	Inhalation 12-hour TWA	Central Tendency	202	323	1.2E−05	2,018 (APF 10)	3,234 (APF 10)	1.2E−06 (APF 10)
				High-End	6.9	11	4.6E−04	69 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)
		ONU [c]	Inhalation 12-hour TWA	Central Tendency	578	926	4.3E−06	–	–	–
				High-End	164	262	1.9E−05	–	–	–
Processing/ Processing as a reactant	Monomer used in polymerization process (synthetic rubber manufacturing; plastic material and resin manufacturing)	Worker [d]	Inhalation 8-hour TWA	Central Tendency	**13**	**14**	**2.9E−04**	127 (APF 10)	136 (APF 10)	2.9E−05 (APF 10)
				High-End	**0.30**	**0.32**	**1.6E−02**	**15** (APF 50)	**16** (APF 50)	**3.2E−04** (APF 50)
		ONU [c]	Inhalation 8-hour TWA	Central Tendency	438	469	8.4E−06	–	–	–
				High-End	51	54	9.4E−05	–	–	–

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing – incorporation into formulation, mixture, or reaction product	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities)	Infrastructure/Distribution Operations [a]	Inhalation 8-hour TWA	Central Tendency	906	970	4.1E−06	9,061 (APF 10)	9,701 (APF 10)	4.1E−07 (APF 10)
				High-End	**11**	**12**	**4.2E−04**	114 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)
		Infrastructure/Distribution Operations – Nonroutine [a]	Inhalation 8-hour TWA	Central Tendency	60	725	5.4E−06	596 (APF 10)	7,251 (APF 10)	5.4E−07 (APF 10)
				High-End	28	342	1.5E−05	281 (APF 10)	3,422 (APF 10)	1.5E−06 (APF 10)
		Instrument and Electrical [b]	Inhalation 8-hour TWA	Central Tendency	1.9E04	2.1E04	1.9E−07	1.9E05 (APF 10)	2.1E05 (APF 10)	1.9E−08 (APF 10)
				High-End	49	53	9.6E−05	494 (APF 10)	528 (APF 10)	9.6E−06 (APF 10)
		Instrument and Electrical – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	165	2,002	2.0E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.0E−07 (APF 10)
				High-End	165	2,002	2.5E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.5E−07 (APF 10)
		Instrument and Electrical – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	463	5,636	7.0E−07	4,632 (APF 10)	5.6E04 (APF 10)	7.0E−08 (APF 10)
				High-End	57	689	7.4E−06	567 (APF 10)	6,893 (APF 10)	7.4E−07 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Bench-mark = 1E−04)**	**Intermediate Non-Cancer (Benchmark MOE = 30)**	**Chronic Non-Cancer (Benchmark MOE = 30)**	**Cancer (Benchmark = 1E−04)**
Processing/ Processing – incorporation into formulation, mixture, or reaction product *(continued)*	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities) *(continued)*	Laboratory Technician [b]	Inhalation 8-hour TWA	Central Tendency	735	787	5.0E−06	7,351 (APF 10)	7,870 (APF 10)	5.0E−07 (APF 10)
				High-End	**21**	**22**	**2.3E−04**	210 (APF 10)	225 (APF 10)	2.3E−05 (APF 10)
		Machinery and Specialists [b]	Inhalation 8-hour TWA	Central Tendency	5,468	5855	6.7E−07	5.5E04 (APF 10)	5.9E04 (APF 10)	6.7E−08 (APF 10)
				High-End	**20**	**22**	**2.4E−04**	202 (APF 10)	217 (APF 10)	2.4E−05 (APF 10)
		Machinery and Specialists – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	984	1.2E04	3.3E−07	9,844 (APF 10)	1.2E05 (APF 10)	3.3E−08 (APF 10)
				High-End	656	7,984	6.4E−07	6,563 (APF 10)	8.0E04 (APF 10)	6.4E−08 (APF 10)
		Maintenance [b]	Inhalation 8-hour TWA	Central Tendency	333	357	1.1E−05	3,331 (APF 10)	3,566 (APF 10)	1.1E−06 (APF 10)
				High-End	**7.1**	**7.6**	**6.7E−04**	71 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)
		Maintenance – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	65	787	5.0E−06	647 (APF 10)	7,867 (APF 10)	5.0E−07 (APF 10)
				High-End	36	433	1.2E−05	356 (APF 10)	4,334 (APF 10)	1.2E−06 (APF 10)
		Maintenance – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	466	5,667	7.0E−07	4,658 (APF 10)	5.7E04 (APF 10)	7.0E−08 (APF 10)
				High-End	**1.5**	**19**	**2.7E−04**	39 (APF 25)	188 (APF 10)	2.7E−05 (APF 10)
		Operations Onsite [b]	Inhalation 8-hour TWA	Central Tendency	1.4E04	1.5E04	2.7E−07	1.4E05 (APF 10)	1.5E05 (APF 10)	2.7E−08 (APF 10)
				High-End	38	40	**1.3E−04**	376 (APF 10)	403 (APF 10)	1.3E−05 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing – incorporation into formulation, mixture, or reaction product *(continued)*	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities) *(continued)*	Operations Onsite – Nonroutine [b]	Inhalation 8-hour TWA	Central Tendency	689	8,384	4.7E−07	6,891 (APF 10)	8.4E04 (APF 10)	4.7E−08 (APF 10)
				High-End	165	2,002	2.5E−06	1,646 (APF 10)	2.0E04 (APF 10)	2.5E−07 (APF 10)
		Operations Onsite – Turnaround [b]	Inhalation 8-hour TWA	Central Tendency	3.9E05	4.8E06	8.3E−10	3.9E06 (APF 10)	4.8E07 (APF 10)	8.3E−11 (APF 10)
				High-End	113	1,377	3.7E−06	1,132 (APF 10)	1.4E04 (APF 10)	3.7E−07 (APF 10)
		Safety Health and Engineering [b]	Inhalation 8-hour TWA	Central Tendency	303	324	1.2E−05	3,027 (APF 10)	3,241 (APF 10)	1.2E−06 (APF 10)
				High-End	10	11	4.6E−04	103 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)
		ONU [c]	Inhalation 8-hour TWA	Central Tendency	866	928	4.3E−06	–	–	–
				High-End	245	263	1.9E−05	–	–	–
		Infrastructure/ Distribution Operations [a]	Inhalation 12-hour TWA	Central Tendency	604	968	4.1E−06	6,041 (APF 10)	9,682 (APF 10)	4.1E−07 (APF 10)
				High-End	**7.6**	**12**	**4.2E−04**	76 (APF 10)	122 (APF 10)	4.2E−05 (APF 10)
		Infrastructure/ Distribution Operations – Nonroutine [a]	Inhalation 12-hour TWA	Central Tendency	40	483	8.2E−06	397 (APF 10)	4,834 (APF 10)	8.2E−07 (APF 10)
				High-End	**19**	228	2.2E−05	188 (APF 10)	2,281 (APF 10)	2.2E−06 (APF 10)
		Instrument and Electrical [b]	Inhalation 12-hour TWA	Central Tendency	1.3E04	2.1E04	1.9E−07	1.3E05 (APF 10)	2.1E05 (APF 10)	1.9E−08 (APF 10)
				High-End	33	53	9.7E−05	329 (APF 10)	527 (APF 10)	9.7E−06 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing – incorporation into formulation, mixture, or reaction product *(continued)*	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities) *(continued)*	Instrument and Electrical – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	110	1,335	3.0E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.0E−07 (APF 10)
				High-End	110	1,335	3.8E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.8E−07 (APF 10)
		Instrument and Electrical – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	309	3,757	1.0E−06	3,088 (APF 10)	3.8E04 (APF 10)	1.0E−07 (APF 10)
				High-End	38	460	1.1E−05	378 (APF 10)	4,595 (APF 10)	1.1E−06 (APF 10)
		Laboratory Technician [b]	Inhalation 12-hour TWA	Central Tendency	490	785	5.0E−06	4,900 (APF 10)	7,854 (APF 10)	5.0E−07 (APF 10)
				High-End	**14**	**22**	**2.3E−04**	140 (APF 10)	224 (APF 10)	2.3E−05 (APF 10)
		Machinery and Specialists [b]	Inhalation 12-hour TWA	Central Tendency	3,646	5,843	6.8E−07	3.6E04 (APF 10)	5.8E04 (APF 10)	6.8E−08 (APF 10)
				High-End	**13**	**22**	**2.4E−04**	135 (APF 10)	216 (APF 10)	2.4E−05 (APF 10)
		Machinery and Specialists – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	656	7,984	4.9E−07	6,563 (APF 10)	8.0E04 (APF 10)	4.9E−08 (APF 10)
				High-End	438	5,323	9.6E−07	4,375 (APF 10)	5.3E04 (APF 10)	9.6E−08 (APF 10)
		Maintenance [b]	Inhalation 12-hour TWA	Central Tendency	222	356	1.1E−05	2,220 (APF 10)	3,559 (APF 10)	1.1E−06 (APF 10)
				High-End	**4.8**	**7.6**	**6.7E−04**	48 (APF 10)	76 (APF 10)	6.7E−05 (APF 10)
		Maintenance – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	43	524	7.5E−06	431 (APF 10)	5,245 (APF 10)	7.5E−07 (APF 10)
				High-End	**24**	289	1.8E−05	237 (APF 10)	2,889 (APF 10)	1.8E−06 (APF 10)

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing – incorporation into formulation, mixture, or reaction product *(continued)*	Intermediate (petrochemical manufacturing) Other (oil and gas drilling, extraction, and support activities) *(continued)*	Maintenance – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	311	3,778	1.0E−06	3,105 (APF 10)	3.8E04 (APF 10)	1.0E−07 (APF 10)
				High-End	**1.0**	**13**	**4.1E−04**	51 (APF 50)	125 (APF 10)	4.1E−05 (APF 10)
		Operations Onsite [b]	Inhalation 12-hour TWA	Central Tendency	9,241	1.5E04	2.7E−07	9.2E04 (APF 10)	1.5E05 (APF 10)	2.7E−08 (APF 10)
				High-End	**25**	40	**1.3E−04**	251 (APF 10)	402 (APF 10)	1.3E−05 (APF 10)
		Operations Onsite – Nonroutine [b]	Inhalation 12-hour TWA	Central Tendency	459	5,589	7.1E−07	4,594 (APF 10)	5.6E04 (APF 10)	7.1E−08 (APF 10)
				High-End	110	1,335	3.8E−06	1,097 (APF 10)	1.3E04 (APF 10)	3.8E−07 (APF 10)
		Operations Onsite – Turnaround [b]	Inhalation 12-hour TWA	Central Tendency	2.6E05	3.2E06	1.2E−09	2.6E06 (APF 10)	3.2E07 (APF 10)	1.2E−10 (APF 10)
				High-End	75	918	5.5E−06	755 (APF 10)	9,181 (APF 10)	5.5E−07 (APF 10)
		Safety Health and Engineering [b]	Inhalation 12-hour TWA	Central Tendency	202	323	1.2E−05	2,018 (APF 10)	3,234 (APF 10)	1.2E−06 (APF 10)
				High-End	**6.9**	**11**	**4.6E−04**	69 (APF 10)	110 (APF 10)	4.6E−05 (APF 10)
		ONU [c]	Inhalation 12-hour TWA	Central Tendency	578	926	4.3E−06	–	–	–
				High-End	164	262	1.9E−05	–	–	–

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Processing/ Processing – incorporation into formulation, mixture, or reaction product Processing/ Processing – incorporation into article	Plasticizer (asphalt paving, roofing, and coating materials manufacturing) Monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing) Monomer (rubber product manufacturing)	Worker [d] (Compounding)	Inhalation 8-hour TWA	Central Tendency	7,219	7,729	5.1E−07	7.2E04 (APF 10)	7.7E04 (APF 10)	5.1E−08 (APF 10)
				High-End	**24**	**26**	**2.0E−04**	243 (APF 10)	260 (APF 10)	2.0E−05 (APF 10)
		ONU [c] (Compounding)	Inhalation 8-hour TWA	Central Tendency	7,219	7,729	5.1E−07	–	–	–
				High-End	7,219	7,729	6.6E−07	–	–	–
		Worker [d] (Compounding)	Inhalation 12-hour TWA	Central Tendency	33	53	7.5E−05	329 (APF 10)	528 (APF 10)	7.5E−06 (APF 10)
				High-End	**11**	**18**	**2.9E−04**	110 (APF 10)	177 (APF 10)	2.9E−05 (APF 10)
		ONU [c] (Compounding)	Inhalation 12-hour TWA	Central Tendency	33	53	7.5E−05	–	–	–
				High-End	33	53	9.6E−05	–	–	–
		Worker [d] (Converting)	Inhalation 8-hour TWA	Central Tendency	1.0E04	1.1E04	3.7E−07	1.0E05 (APF 10)	1.1E05 (APF 10)	3.7E−08 (APF 10)
				High-End	**28**	**30**	**1.7E−04**	279 (APF 10)	299 (APF 10)	1.7E−05 (APF 10)
		ONU [c] (Converting)	Inhalation 8-hour TWA	Central Tendency	1.0E04	1.1E04	3.7E−07	–	–	–
				High-End	1.0E04	1.1E04	4.7E−07	–	–	–
		Worker [d] (Converting)	Inhalation 12-hour TWA	Central Tendency	33	53	7.5E−05	329 (APF 10)	528 (APF 10)	7.5E−06 (APF 10)
				High-End	**11**	**18**	**2.9E−04**	110 (APF 10)	177 (APF 10)	2.9E−05 (APF 10)
		ONU [c] (Converting)	Inhalation 12-hour TWA	Central Tendency	33	53	7.5E−05	–	–	–
				High-End	33	53	9.6E−05	–	–	–

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Commercial Use/ Other use	Laboratory chemicals	Laboratory Technician [b]	Inhalation 8-hour TWA	Central Tendency	735	787	5.0E−06	7,351 (APF 10)	7,870 (APF 10)	5.0E−07 (APF 10)
				High-End	**21**	**22**	**2.3E−04**	210 (APF 10)	225 (APF 10)	2.3E−05 (APF 10)
		ONU [c]	Inhalation 8-hour TWA	Central Tendency	866	928	4.3E−06	–	–	–
				High-End	245	263	1.9E−05	–	–	–
		Laboratory Technician [b]	Inhalation 12-hour TWA	Central Tendency	490	785	5.0E−06	4,900 (APF 10)	7,854 (APF 10)	5.0E−07 (APF 10)
				High-End	**14**	**22**	**2.3E−04**	140 (APF 10)	224 (APF 10)	2.3E−05 (APF 10)
		ONU [c]	Inhalation 12-hour TWA	Central Tendency	578	926	4.3E−06	–	–	–
				High-End	164	262	1.9E−05	–	–	–
Industrial Use / Adhesives and sealants Commercial Use / Paints and coatings Commercial Use / Adhesives and sealants	Adhesives and sealants, including epoxy resins Paints and coatings, including aerosol spray paint Adhesives and sealants, including epoxy resins	Worker [d]	Inhalation 8-hour TWA	Central Tendency	111	119	3.3E−05	1,109 (APF 10)	1,187 (APF 10)	3.3E−06 (APF 10)
				High-End	55	59	8.6E−05	554 (APF 10)	594 (APF 10)	8.6E−06 (APF 10)
		ONU [c]	Inhalation 8-hour TWA	Central Tendency	111	119	3.3E−05	–	–	–
				High-End	111	119	4.3E−05	–	–	–
Disposal	Disposal	Worker [a] (Recyling full shift)	Inhalation 8-hour TWA	Central Tendency	**22**	**23**	**1.7E−04**	218 (APF 10)	233 (APF 10)	1.7E−05 (APF 10)
				High-End	**3.9**	**4.1**	**1.2E−03**	39 (APF 10)	41 (APF 10)	4.9E−05 (APF 25)
		ONU [c] (Recyling full shift)	Inhalation 8-hour TWA	Central Tendency	**22**	**23**	**1.7E−04**	–	–	–
				High-End	**22**	**23**	**2.2E−04**	–	–	–

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)
Disposal *(continued)*	Disposal *(continued)*	Worker [a] (Recyling task-length)	Inhalation 8-hour TWA	Central Tendency	295	316	1.2E−05	2,955 (APF 10)	3,163 (APF 10)	1.2E−06 (APF 10)
				High-End	52	56	9.1E−05	520 (APF 10)	557 (APF 10)	9.1E−06 (APF 10)
		ONU [c] (Recyling task-length)	Inhalation 8-hour TWA	Central Tendency	295	316	1.2E−05	–	–	–
				High-End	295	316	1.6E−05	–	–	–
		Worker [a] (Waste handling, treatment, and disposal [full shift])	Inhalation 8-hour TWA	Central Tendency	**22**	**23**	**1.7E−04**	218 (APF 10)	233 (APF 10)	1.7E−05 (APF 10)
				High-End	**3.9**	**4.1**	**1.2E−03**	39 (APF 10)	41 (APF 10)	4.9E−05 (APF 25)
		ONU [c] (Waste handling, treatment, and disposal [full shift])	Inhalation 8-hour TWA	Central Tendency	**22**	**23**	**1.7E−04**	–	–	–
				High-End	**22**	**23**	**2.2E−04**	–	–	–
		Worker [a] (Waste handling, treatment, and disposal [task-length])	Inhalation 8-hour TWA	Central Tendency	295	316	1.2E−05	2,955 (APF 10)	3,163 (APF 10)	1.2E−06 (APF 10)
				High-End	52	56	9.1E−05	520 (APF 10)	557 (APF 10)	9.1E−06 (APF 10)
		ONU [c] (Waste handling, treatment, and disposal [task-length])	Inhalation 8-hour TWA	Central Tendency	295	316	1.2E−05	–	–	–
				High-End	295	316	1.6E−05	–	–	–

Note: **bold** and gray-shaded text indicates that an MOE is below the MOE benchmark value of 30 or above a cancer risk of 1×10^{-4}.
APF = Assigned Protection Factor; MOE = margin of exposure; OES = occupational exposure scenario; PPE = personal protection equipment; SEG = similarly exposed group; TWA = time-weighted average
[a] According to Table 5-4, there is evidence that specific tasks associated with this job group always involve wearing of respirators for some facilities and COUs. However, a consistent level of respiratory protection cannot be assumed across a job group, and EPA does not have information to suggest that respirators are worn for the entirety of the work day for any job group/SEG.
[b] According to Table 5-4, there is evidence that specific tasks associated with this job group sometimes involve wearing of respirators. However, a consistent level of respiratory protection cannot be assumed across a job group, and EPA does not have information to suggest that respirators are worn for the entirety of the work day for any job group/SEG.
[c] Respirator use is not expected for occupational non-users (ONUs).
[d] There is insufficient information to determine respirator use for workers in this OES.

Life Cycle Stage/ Category(ies)	Subcategory	Job Group/SEG	Exposure Route and Duration	Exposure Level	Risk Estimates for No PPE			PPE to Mitigate Risk (Max APF = 50) [e]		
					Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Bench-mark = 1E−04)	Intermediate Non-Cancer (Benchmark MOE = 30)	Chronic Non-Cancer (Benchmark MOE = 30)	Cancer (Benchmark = 1E−04)

[e] APF = 50 is the maximum included in this table. Higher respiratory protection levels are unlikely to be used for a full shift duration.

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APPENDICES

Appendix A KEY ABBREVIATIONS AND ACRONYMS

ABS	Acrylonitrile-butadiene-styrene
ACC	American Chemistry Council
ADAF	Age-dependent adjustment factor
AEGL	Acute Exposure Guideline Level
AMTIC	Ambient Monitoring Technology Information Center
APF	Assigned Protection Factor
ATSDR	Agency for Toxic Substances and Disease Registry
CAA	Clean Air Act
CASRN	Chemical Abstracts Service Registry Number
CBI	Confidential business information
CDR	Chemical Data Reporting
CEM	Consumer Exposure Model
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COU	Condition of use
DOD	Department of Defense (U.S.)
ECEL	Existing Chemical Exposure Limit
EPA	Environmental Protection Agency (U.S.)
ESD	Emission scenario document
GACT	Generally Available Control Technology
GS	Generic scenario
HAP	Hazardous Air Pollutant
HEC	Human Equivalent Concentration
HED	Human Equivalent Dose
HEM	Human Exposure Model
IIOAC	Integrated Indoor-Outdoor Air Calculator
IRIS	Integrated Risk Information System
(I)UR	(Inhalation) unit risk
ISHA	Industrial Safety and Health Act
K_{OA}	Octanol:air partition coefficient
K_{OC}	Organic carbon:water partition coefficient
LADC	Lifetime average daily concentration
LCD	Life cycle diagram
LOD	Limit of detection
LOQ	Limit of quantification
LPG	Liquified petroleum gas
MACT	Maximum achievable control technology
MDL	Minimum detection limit
MLE	Maximum likelihood estimation
MOE	Margin of exposure
NAICS	North American Industry Classification System
NEI	National Emissions Inventory
NICNAS	National Industrial Chemicals Notification and Assessment Scheme (Australia)
NIOSH	National Institute for Occupational Safety and Health (U.S.)
NPL	National Priorities List

NPRI	National Pollutant Release Inventory
NTP	National Toxicology Program
OAR	Office of Air and Radiation (EPA)
OCSPP	Office of Chemical Safety and Pollution Prevention (EPA)
OECD	Organisation for Economic Co-operation and Development
OEL	Occupational exposure limits
OES	Occupational exposure scenario
OEV	Occupational exposure value
ONU	Occupational non-user
OPPT	Office of Pollution Prevention and Toxics (EPA)
OSHA	Occupational Safety and Health Administration (U.S.)
PBZ	Personal breathing zone
PECO	Populations, exposures, comparators, and outcomes
PEL	Permissible exposure limit
PESS	Potentially exposed or susceptible subpopulations
POD	Point of departure
POTW	Publicly owned treatment works
PPE	Personal protective equipment
PV	Production volume
PWS	Public water system
RTR	Risk and technology reviews
SACC	Science Advisory Committee on Chemicals
SARA	Superfund Amendments and Reauthorization Act
SBR	Styrene-butadiene rubber
SDS	Safety data sheet
SDWA	Safe Drinking Water Act
SEG	Similarly exposed group
SHE	Safety, Health, and Environment
SOCMI	Synthetic Organic Chemical Manufacturing Industry
STEL	Short-term exposure limit
TLV	Threshold limit value
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TSD	Technical support document
TWA	Time-weighted average
UCMR	Unregulated Contaminants Monitoring Rule
UF	Uncertainty factor
U.S.	United States
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WHO	World Health Organization
WQP	Water Quality Portal
WWT	Wastewater treatment

Appendix B REGULATORY AND ASSESSMENT HISTORY

The chemical substance, 1,3-butadiene, is subject to federal and state laws and regulations in the United States (Sections B.1 and B.2). Regulatory actions by other governments, Tribes, and international agreements applicable to 1,3-butadiene are listed in Sections B.3 and the governmental assessment history is presented in Section B.4.

B.1 Federal Laws and Regulations

Table_Apx B-1. Federal Laws and Regulations

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
Toxic Substances Control Act (TSCA) – section 6(b)	EPA is directed to identify high-priority chemical substances for risk evaluation; and conduct risk evaluations on at least 20 high priority substances no later than three and one-half years after the date of enactment of the Frank R. Lautenberg Chemical Safety for the 21st Century Act.	1,3-Butadiene is one of the 20 chemicals EPA designated as a High-Priority Substance for risk evaluation under TSCA (84 FR 71924, December 30, 2019). Designation of 1,3-butadiene as a high-priority substance constitutes the initiation of the risk evaluation on the chemical.
Toxic Substances Control Act (TSCA) – section 8(a)	The TSCA section 8(a) Chemical Data Reporting (CDR) Rule requires manufacturers (including importers) to give EPA basic exposure-related information on the types, quantities, and uses of chemical substances produced domestically and imported into the United States.	1,3-Butadiene manufacturing (including importing), processing, and use information is reported under the CDR rule (85 FR 20122, April 2, 2020).
Toxic Substances Control Act (TSCA) – section 8(b)	EPA must compile, keep current, and publish a list (the TSCA Inventory) of each chemical substance manufactured (including imported) or processed in the United States.	1,3-Butadiene was on the initial TSCA Inventory and therefore was not subject to EPA's new chemicals review process under TSCA section 5 (60 FR 16309, March 29, 1995).
Toxic Substances Control Act (TSCA) – section 8(e)	Manufacturers (including importers), processors, and distributors must immediately notify EPA if they obtain information that supports the conclusion that a chemical substance or mixture presents a substantial risk of injury to health or the environment.	20 risk reports received for 1,3-butadiene (2017, 2011, 2008–2007, 2005, 2002–1997, 1995–1994, 1992, 1990) (U.S. EPA, ChemView).
Emergency Planning and Community Right-to-Know Act (EPCRA) – section 313	Requires annual reporting from facilities in specific industry sectors that employ 10 or more full-time equivalent employees and that manufacture, process or otherwise use a Toxics Release Inventory (TRI)-listed chemical in quantities above threshold levels. A facility that meets reporting requirements must submit a reporting form for each chemical for which it triggered reporting, providing data across a variety of categories, including activities and uses of the chemical, releases and other waste management (*e.g.*, quantities recycled, treated, combusted) and	1,3-Butadiene is a listed substance subject to reporting requirements under 40 CFR 372.65, effective as of January 01, 1987.

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	pollution prevention activities (under section 6607 of the Pollution Prevention Act). These data include on- and off-site data as well as multimedia data (*i.e.*, air, land and water).	
Clean Air Act (CAA) – section 112(b)	Defines the original list of 189 hazardous air pollutants (HAPs). Under 112(c) of the CAA, EPA must identify and list source categories that emit HAPs and then set emission standards for those listed source categories under CAA Section 112(d). CAA Section 112(b)(3)(A) specifies that any person may petition the Administrator to modify the list of HAPs by adding or deleting a substance. Since 1990, EPA has removed 2 pollutants from the original list leaving 187 at present.	1,3-Butadiene is listed as a HAP (42 U.S.C. 7412).
CAA – section 112(d)	Directs EPA to establish, by rule, NESHAPs for each category or subcategory of listed major sources and area sources of HAPs (listed pursuant to Section 112(c)). For major sources, the standards must require the maximum degree of emission reduction that EPA determines is achievable by each particular source category. This is generally referred to as maximum achievable control technology (MACT). For area sources, the standards must require generally available control technology (GACT) though may require MACT.	EPA has established NESHAPs for a number of source categories that emit 1,3-butadiene to air.
CAA – sections 112(d) and 112(f)	Risk and technology review (RTR) of Section 112(d) national emission standards for hazardous air pollutants (NESHAP). Section 112(f)(2) requires EPA to conduct risk assessments for each source category subject to section 112(d) NESHAP that require maximum achievable control technology (MACT), and to determine if additional standards are needed to reduce remaining risks. Section 112(d)(6) requires EPA to review and revise the emission standards, as necessary, taking into account developments in practices, processes, and control technologies.	EPA has promulgated a number of RTR NESHAP and will do so, as required, for the remaining source categories with NESHAP.
CAA – section 183(e)	Section 183(e) requires EPA to list the categories of consumer and commercial products that account for at least 80% of all volatile organic compound (VOC) emissions in areas that violate the National Ambient Air Quality Standards (NAAQS) for ozone and to issue standards for these categories that require “best available controls.” In lieu of	1,3-Butadiene is listed under the National Volatile Organic Compound Emission Standards for Aerosol Coatings (40 CFR part 59, subpart E). 1,3-Butadiene has a reactivity factor of 13.58 g O^3/g VOC.

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	regulations, EPA may issue control techniques guidelines if the guidelines are determined to be substantially as effective as regulations.	
Safe Drinking Water Act (SDWA) – section 1412(b)	Every 5 years, EPA must publish a list of contaminants that: (1) are currently unregulated, (2) are known or anticipated to occur in public water systems (PWSs) and (3) may require regulations under SDWA. EPA must also determine whether to regulate at least 5 contaminants from the list every 5 years.	1,3-Butadiene was identified on both the Third (2009) and Fourth (2016) Contaminant Candidate Lists (CCL) (74 FR 51850, October 8, 2009) (81 FR 81099, November 17, 2016).
SDWA – section 1445(a)	Every 5 years, EPA must issue a new list of no more than 30 unregulated contaminants to be monitored by PWSs. The data obtained must be entered into the National Drinking Water Contaminant Occurrence Database.	1,3-Butadiene was identified in the Third Unregulated Contaminant Monitoring Rule (UCMR3), issued in 2012 (77 FR 26072, May 2, 2012).
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) – sections 102(a) and 103	Authorizes EPA to promulgate regulations designating as hazardous substances those substances which, when released into the environment, may present substantial danger to the public health or welfare or the environment. EPA must also promulgate regulations establishing the quantity of any hazardous substance the release of which must be reported under section 103. Section 103 also requires persons in charge of vessels or facilities to report to the National Response Center if they have knowledge of a release of a hazardous substance above the reportable quantity threshold.	1,3-Butadiene is a hazardous substance under CERCLA. Releases of 1,3-butadiene in excess of 10 lb must be reported (40 CFR 302.4).
Superfund Amendments and Reauthorization Act (SARA)	Requires the Agency to revise the hazardous ranking system and update the National Priorities List (NPL) of hazardous waste sites, increases state and citizen involvement in the superfund program and provides new enforcement authorities and settlement tools**.**	1,3-Butadiene is listed on SARA, an amendment to CERCLA and the CERCLA Priority List of Hazardous Substances. This list includes substances most commonly found at facilities on the CERCLA NPL that have been deemed to pose the greatest threat to public health.
Other federal statutes/regulations		
Occupational Safety and Health Act	Requires employers to provide their workers with a place of employment free from recognized hazards to safety and health, such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress or unsanitary conditions (29 U.S.C Section 651 et seq.).	OSHA established a PEL for 1,3-butadiene of 1 ppm / 5 ppm short-term exposure limit (STEL) as an 8-hour, time-weighted average (TWA) (29 CFR 1910.1051).

Statutes/Regulations	Description of Authority/Regulation	Description of Regulation
	Under the Act, the Occupational Safety and Health Administration (OSHA) can issue occupational safety and health standards including such provisions as permissible exposure limits (PELs), exposure monitoring, engineering and administrative control measures, and respiratory protection.	
All hyperlinks in this table were last accessed on December 5, 2025.		

B.2 State Laws and Regulations

Table_Apx B-2. State Laws and Regulations

State Actions	Description of Action
State Air Regulations	Allowable Ambient Levels: New Hampshire (Env-A 1400: Regulated Toxic Air Pollutants). Rhode Island (Air Pollution Regulation No. 22).
State PELs	California (PEL of 1 ppm and a STEL of 5) (Cal Code Regs. Title 8, § 5155) Hawaii PEL: 1 ppm (Hawaii Administrative Rules Section 12-60-50).
State Right-to-Know Acts	Massachusetts (105 Code Mass. Regs. § 670.000 Appendix A), New Jersey (N.J.A.C. 7:1G) and Pennsylvania (P.L. 734, No. 159 and 34 Pa. Code § 323).
Chemicals of High Concern to Children	Two states have adopted reporting laws for chemicals in children's products containing 1,3-butadiene, including Maine (38 MRSA Chapter 16-D) and Minnesota (Toxic Free Kids Act Minn. Stat. 116.9401 to 116.9407).
Other	California listed 1,3-butadiene on Proposition 65 in 1998 due to cancer, and in 2004 due to developmental toxicity and female/male reproductive toxicity (Cal Code Regs. Title 27, § 27001). 1,3-Butadiene is listed as a Candidate Chemical under California's Safer Consumer Products Program established under Health and Safety Code § 25252 and 25253 (California, Candidate Chemicals List). California also lists 1,3-butadiene as a designated priority chemical for biomonitoring under criteria established by California SB 1379 (Biomonitoring California, Priority Chemicals, February 2019). 1,3-Butadiene is on the MA Toxic Use Reduction Act (TURA) list of 2019 (301 CMR 41.00).
All hyperlinks in this table were last accessed on December 5, 2025.	

B.3 International Laws and Regulations

Table_Apx B-3. International Laws and Regulations

Country/ Tribe/ Organization	Requirements and Restrictions
Canada	1,3-Butadiene is on the Canadian List of Toxic Substances (Canadian Environmental Protection Act 1999 Schedule 1). Other regulations include: Canada's National Pollutant Release Inventory (NPRI) Part 1A as a VOC.
European Union	1,3-Butadiene was evaluated under the 2014 Community rolling action plan (CoRAP) under regulation European Commission (EC) No1907/2006. –

Country/ Tribe/ Organization	Requirements and Restrictions
	REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals; European Chemical Agency (ECHA) database). 1,3-Butadiene is registered for use in the EU with no restrictions CoRAP (Final).
Australia	1,3-Butadiene was assessed under Human Health Tier II of the Inventory Multi-Tiered Assessment and Prioritisation (IMAP). Uses reported include: • producing synthetic rubber (used to manufacture automotive tires and tire products); • producing plastics such as acrylics, high impact polystyrene and acrylonitrile-butadiene-styrene (ABS) resin plastics, nylon and neoprene; • producing • resins; • processing petroleum; • as a chemical intermediate in producing some fungicides; and • In manufacturing latex adhesives and paints (NICNAS, 2013, Human Health Tier II assessment for 1,3-butadiene).
Japan	1,3-Butadiene is regulated in Japan under the following legislation: • Act on the Evaluation of Chemical Substances and Regulation of Their Manufacture, etc. (Chemical Substances Control Law; CSCL) • Act on Confirmation, etc. of Release Amounts of Specific Chemical Substances in the Environment and Promotion of Improvements to the Management Thereof • Industrial Safety and Health Act (ISHA) • Air Pollution Control Law
Basel Convention	Solid Plastic Waste is listed as a category of waste under the Basel Convention. Although the United States is not currently a party to the Basel Convention, this treaty still affects U.S. importers and exporters**.**
Australia, Austria, Belgium, Canada, Denmark, European Union, Finland, France, Germany, Hungary, Ireland, Latvia, New Zealand, People's Republic of China, Poland, Romania, Singapore, South Korea, Spain, Sweden, Switzerland, The Netherlands, United Kingdom	Occupational exposure limits (OELs) for 1,3-butadiene (GESTIS International limit values for chemical agents (OELs database).
All hyperlinks in this table were last accessed on December 5, 2025.	

B.4 Government Assessment History

Only governmental assessments published since 2000 are included in Table_Apx B-4 below. This list represents prominent assessments referenced either directly or indirectly by this risk evaluation or supporting documents and others identified through the systematic review process. It does not include private organizational or academic assessments and may not be inclusive of all national or international governmental assessments.

Table_Apx B-4. Assessment History of 1,3-Butadiene

Authoring Organization	Publication
EPA publications	
U.S. EPA, Office of Pollution Prevention and Toxics (OPPT)	TSCA Work Plan for Chemical Assessments: 2014 Update (U.S. EPA, 2014b)
U.S. EPA, Integrated Risk Information System (IRIS)	Health Assessment of 1,3-Butadiene (U.S. EPA, 2002b)
Other U.S. agencies	
Agency for Toxic Substances and Disease Registry (ATSDR)	Toxicological Profile for 1,3-Butadiene (ATSDR, 2012)
U.S. States	
California, California Environmental Protection Agency, Office of Environmental Health Hazard Assessments	1,3-Butadiene Reference Exposure Levels (OEHHA, 2013)
Texas, Texas Commission on Environmental Quality	A Chronic Reference Value for 1,3-Butadiene Based on an Updated Noncancer Toxicity Assessment (Grant et al., 2010)
International	
Australia, Australian Department of Health, National Industrial Chemicals Notification and Assessment Scheme (NICNAS)	1,3-Butadiene: Human health tier II assessment (NICNAS, 2013)
International Agency for Research on Cancer (IARC), IARC monograph	Chemical agents and related occupations: A review of human carcinogens (IARC, 2012)
Netherlands, National Institute for Public Health and the Environment	Environmental risk limits for 1,3-butadiene (RIVM, 2009)
European Union, European Chemicals Bureau, Institute for Health and Consumer Protection	European Union risk assessment report: 1,3-Butadiene (ECB, 2002)
World Health Organization (WHO)	1,3-Butadiene: Human health aspects (WHO, 2001)
Canada, Environment Canada, Health Canada	Priority Substances List Assessment Report: 1,3-Butadiene (Health Canada, 2000)
All hyperlinks in this table were last accessed on December 5, 2025.	

Appendix C LIST OF TECHNICAL SUPPORT DOCUMENTS AND SUPPLEMENTAL FILES

The below list indicates all TSDs and supplemental files associated with this risk evaluation. These include discipline-specific assessments, systematic review results, risk calculations, modeling outputs, and public communication documents. Files are numbered corresponding with the filenames uploaded to the dockets ("1" is for this risk evaluation): https://www.regulations.gov/docket/EPA-HQ-OPPT-2018-0451 and https://www.regulations.gov/docket/EPA-HQ-OPPT-2024-0425.

Associated **Technical Support Documents** – Provide additional details and information on physical chemistry, fate, exposure, hazard, and risk assessments.

2. *Physical Chemistry, Fate, and Transport Assessment for 1,3-Butadiene* (U.S. EPA, 2025ae)
3. *Environmental Release and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r)
4. *Environmental Media Concentrations for 1,3-Butadiene* (U.S. EPA, 2025q)
5. *General Population Exposure for 1,3-Butadiene* (U.S. EPA, 2025u)
6. *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y)

Associated **Systematic Review Protocol and Data Quality Evaluation and Data Extraction** Documents – Provide additional detail and information on systematic review methodologies used as well as the data quality evaluations and extractions criteria and results.

7. *Systematic Review Protocol for 1,3-Butadiene* (U.S. EPA, 2025aj) – In lieu of an update to the 2021 *Draft Systematic Review Protocol* (U.S. EPA, 2021a), this systematic review protocol for the Risk Evaluation for 1,3-Butadiene describes some clarifications and different approaches that were implemented than those described in the 2021 Draft Systematic Review Protocol in response to (1) SACC comments, (2) public comments, or (3) to reflect chemical-specific risk evaluation needs. This supplemental file may also be referred to as the "1,3-Butadiene Systematic Review Protocol."

8. *Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties for 1,3-Butadiene* (U.S. EPA, 2025m) – Provides a compilation of tables for the data extraction and data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted and evaluated from a data source that has information relevant for the evaluation of physical and chemical properties. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation and Data Extraction Information for Physical and Chemical Properties."

9. *Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport for 1,3-Butadiene* (U.S. EPA, 2025k) – Provides a compilation of tables for the data extraction and data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted and evaluated from a data source that has information relevant for the evaluation for Environmental Fate and Transport. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation and Data Extraction Information for Environmental Fate and Transport."

10. *Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure for 1,3-Butadiene* (U.S. EPA, 2025l) – Provides a compilation of tables for the data extraction and data quality evaluation information for 1,3-butadiene. Each table shows the

data point, set, or information element that was extracted and evaluated from a data source that has information relevant for the evaluation of environmental release and occupational exposure. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation and Data Extraction Information for Environmental Release and Occupational Exposure."

11. *Data Quality Evaluation Information for General Population, Consumer, and Environmental Exposure for 1,3-Butadiene* (U.S. EPA, 2025n) – Provides a compilation of tables for the data extraction for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted from a data source that has information relevant for the evaluation of general population, consumer, and environmental exposure. This supplemental file may also be referred to as the "1,3-Butadiene Data Extraction Information for General Population, Consumer, and Environmental Exposure."

12. *Data Extraction Information for General Population, Consumer, and Environmental Exposure for 1,3-Butadiene* (U.S. EPA, 2025i) – Provides a compilation of tables for the data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was evaluated from a data source that has information relevant for the evaluation of general population, consumer, and environmental exposure. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation Information for General Population, Consumer, and Environmental Exposure."

13. *Further Filtering Results for Human Health Hazard Animal Toxicology and Epidemiology for 1,3-Butadiene* (U.S. EPA, 2025t) – Provides a compilation of tables for study-wide summary information for 1,3-butadiene human health hazard studies. This information was used to "filter" studies that met populations, exposures, comparators, and outcomes (PECO) criteria to determine which studies should undergo data evaluation and extraction based on whether they could potentially support dose-response analysis. This supplemental file may also be referred to as the "1,3-Butadiene Further Filtering Results for Human Health Hazard."

14. *Data Quality Evaluation Information for Human Health Hazard Epidemiology for 1,3-Butadiene* (U.S. EPA, 2025p) – Provides a compilation of tables for the data quality evaluation information for DIDP. Each table shows the data point, set, or information element that was evaluated from a data source that has information relevant for the evaluation of epidemiological information. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation Information for Human Health Hazard Epidemiology."

15. *Data Quality Evaluation Information for Human Health Hazard Animal Toxicology for 1,3-Butadiene* (U.S. EPA, 2025o) – Provides a compilation of tables for the data quality evaluation information for 1,3-butadiene. Each table shows the data point, set, or information element that was evaluated from a data source that has information relevant for the evaluation of human health hazard animal toxicity information. This supplemental file may also be referred to as the "1,3-Butadiene Data Quality Evaluation Information for Human Health Hazard Animal Toxicology."

16. *Data Extraction Information for Human Health Hazard Animal Toxicology and Epidemiology for 1,3-Butadiene* (U.S. EPA, 2025j) – Provides a compilation of tables for the data extraction for 1,3-butadiene. Each table shows the data point, set, or information element that was extracted from a data source that has information relevant for the evaluation human health hazard animal toxicology and epidemiology information. In contrast with other risk evaluations, this file contains dose-response information for every assessed endpoint within each animal toxicology study. This

supplemental file may also be referred to as the "1,3-Butadiene Data Extraction Information for Environmental Hazard and Human Health Hazard Animal Toxicology and Epidemiology."

Associated **Quantitative Analysis** Supplemental Documents:

17. *EPI Suite Modeling Results Supporting Fate Assessment for 1,3-Butadiene* (U.S. EPA, 2025s)

18. *Ambient Monitoring Technology Information Center (AMTIC) Monitoring Data 2016 to 2022 for 1,3-Butadiene* (U.S. EPA, 2025f)

19. *Water Quality Portal (WQP) Monitoring Data 2004 to 2025 for 1,3-Butadiene* (U.S. EPA, 2025al)

20. *Land Releases for 1,3-Butadiene* (U.S. EPA, 2025aa)

21. *Water Releases for 1,3-Butadiene* (U.S. EPA, 2025am)

22. *Air Releases (TRI) for 1,3-Butadiene* (U.S. EPA, 2025e)

23. *Air Releases (NEI 2017) for 1,3-Butadiene* (U.S. EPA, 2025c)

24. *Air Releases (NEI 2020) for 1,3-Butadiene* (U.S. EPA, 2025d)

25. *Adhesives and Sealants Release Model for 1,3-Butadiene* (U.S. EPA, 2025b)

26. *Number of Sites for 1,3-Butadiene* (U.S. EPA, 2025ad)

27. *Benchmark Dose Modeling Results for 1,3-Butadiene* (U.S. EPA, 2025h)

28. *Lifetable Analysis of Leukemia and Bladder Cancer for 1,3-Butadiene* (U.S. EPA, 2025ab)

29. *Risk Calculator for Occupational Exposures for 1,3-Butadiene* (U.S. EPA, 2025af)

30. *Integrated Indoor Outdoor Air Calculator (IIOAC) TRI 2016–2021 Exposure and Risk Analysis for 1,3-Butadiene* (U.S. EPA, 2025z)

31. *Human Exposure Model (HEM) TRI 2016–2021 Exposure and Risk Analysis for 1,3-Butadiene* (U.S. EPA, 2025x)

32. *Human Exposure Models (HEM) NEI 2017 and 2020 General Population Exposure Analysis for 1,3-Butadiene* (U.S. EPA, 2025w)

33. *Human Exposure Models (HEM) NEI 2017 and 2020 Exposure and Risk Analysis for 1,3-Butadiene* (U.S. EPA, 2025v)

34. *Supplemental Information on the Human Exposure Modeling Results for 1,3-Butadiene* (U.S. EPA, 2025ah)

35. *Supplemental Information on the Human Exposure Modeling Results for 1,3-Butadiene (NEI)* (U.S. EPA, 2025ai)

36. *Third Unregulated Contaminant Monitoring Rule Data for 1,3-Butadiene* (U.S. EPA, 2025ak)

37. *1,3-Butadiene Inhalation Monitoring Data Summary* (U.S. EPA, 2025a)

38. *Appendix H Attachment of 1,3-Butadiene Occupational Exposure Assessment* (U.S. EPA, 2025g)

39. *Nontechnical Summary for 1,3-Butadiene* (U.S. EPA, 2025ac)

40. *Summary of and Response to External Peer Review and Public Comments on the Risk Evaluation and Technical Support Documents for 1,3-Butadiene* (U.S. EPA, 2025ag)

Appendix D UPDATES TO 1,3-BUTADIENE CONDITIONS OF USE TABLES

After the final scope, EPA received updated submissions under the CDR reported data. Therefore, EPA is amending the description of certain 1,3-butadiene conditions of use (COUs) under TSCA based on the new submissions, expanding subcategories to accurately represent the Agency's understanding of the use, and consolidating categories already covered in the COU table. Also, EPA is amending an error to a COU in the final scope document (U.S. EPA, 2020c).

Table_Apx D-1. Additions and Name Changes to Categories and Subcategories of Conditions of Use Based on CDR Reporting and Stakeholder Engagement

Life Cycle Stage and Category	Original Subcategory in the Final Scope Document	Occurred Change	Revised Subcategory in the 2025 Risk Evaluation
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; Wholesale and retail trade	Combined intermediate "petrochemical refineries" with petrochemical manufacturing. Removed "wholesale and retail trade" as it was reported in 2020 CDR as "non-incorporative" and "repackaging." Added "paint and coating manufacturing" based on public comments.	Processing – as a reactant – intermediate (adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing; petrochemical manufacturing; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing)
Processing; incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: Petrochemical manufacturing	Changed functional code based on more recent CDR reports.	Processing – incorporation into formulation, mixture, or reaction product – intermediate (petrochemical manufacturing)
Processing; incorporation into formulation, mixture, or reaction product	Other: Adhesive manufacturing, paints and coatings manufacturing, petroleum lubricating oil and grease manufacturing, and all other chemical product and preparation manufacturing	Removed based on public comments and lack of reporting of this use in the most recent CDR cycle.	N/A
Processing; incorporation into formulation, mixture, or reaction product	N/A	Included "Monomers (Plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing)" based on reports in the 2020 CDR cycle.	Processing – incorporation into formulation, mixture, or reaction product – monomers (plastic product manufacturing; plastic material and resin manufacturing; synthetic rubber manufacturing)
Processing; incorporation into formulation, mixture, or reaction product	N/A	Added "Plasticizer (Asphalt paving, roofing, and coating materials manufacturing)" based on reports in the 2024 CDR cycle.	Processing – incorporation into formulation, mixture, or reaction product – plasticizer (asphalt paving, roofing, and coating materials manufacturing)

Life Cycle Stage and Category	Original Subcategory in the Final Scope Document	Occurred Change	Revised Subcategory in the 2025 Risk Evaluation
Processing; incorporation into formulation, mixture, or reaction product	N/A	Added "Other (Oil and gas drilling, extraction, and support activities)" based on reports in the 2024 CDR cycle.	Processing – incorporation into formulation, mixture, or reaction product – other (oil and gas drilling, extraction, and support activities)
Processing – incorporation into article	Other: Polymer in: Rubber and plastic product manufacturing	Recategorized "Other: Polymer in: (Rubber and plastic product manufacturing)" to "Monomer (Rubber product manufacturing)" based on changes in CDR functional codes. Consolidated "Hardener (Rubber Product Manufacturing)" due to one 2024 report listing this as a "hardener" while others are listed under the "Monomer" functional code.	Processing – incorporation into formulation, mixture, or reaction product – monomer (rubber product manufacturing)
Processing; repackaging	Intermediate in: Wholesale and retail trade	Added additionally subcategories to reflect updates from 2020 CDR reporting cycle.	Processing – repackaging – (wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing)
Processing; Use-non-incorporative activities	N/A	Added based on reports in more recent CDR cycles.	Fuel (petroleum refineries)
Industrial Use; Processing aids, specific to petroleum production	Hydraulic fracturing fluids	Removed "Hydraulic fracturing fluids." 1,3-Butadiene is not used for hydraulic fracturing for oil and gas.	N/A
Commercial Use; Fuels and related products	Fuels and related products	Added to the subcategory based on more recent CDR data.	Commercial use: fuels and related products – fuel additive; vehicular or appliance fuels; cooking and heating fuels
Commercial Use; Automotive care products	Automotive care products	Removed as it was not in the recent CDR cycles.	N/A
Commercial Use	Plastic and rubber products not covered elsewhere, including rubber tires	Replaced "plastic and rubber products not covered elsewhere" with new subcategories based on updates to CDR reporting and the 2020 CDR reporting cycle.	Commercial use – articles with routine direct contact during normal use including rubber articles; plastic articles (hard) Commercial use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard)

Life Cycle Stage and Category	Original Subcategory in the Final Scope Document	Occurred Change	Revised Subcategory in the 2025 Risk Evaluation
			Commercial use – synthetic rubber (*e.g.*, rubber tires) Commercial use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles and Commercial use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)
Consumer Use	Plastic and rubber products not covered elsewhere	Replaced "plastic and rubber products not covered elsewhere" with new subcategories based on updates to CDR reporting and the 2020 CDR reporting cycle.	Consumer use – other articles with routine direct contact during normal use including rubber articles; plastic articles (hard) Consumer use – toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard) Consumer use – synthetic rubber (*e.g.*, rubber tires) Consumer use – furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles and Consumer use – packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)
CDR = Chemical Data Reporting			

As indicated in Table_Apx D-1, the changes are based on close examination of the CDR reports, including the 2020 CDR reports that were received after the scope was completed, additional research on the COUs, additional comments from stakeholders, and overall systematic review of the use information.

In addition, EPA did further analysis of the following COUs, which resulted in the changes presented in the table which warrant further explanation because these COUs were changed significantly between the final scope and the published risk evaluation:

- ***Processing; processing as a reactant – intermediate in paint and coating manufacturing:*** EPA represents the paint and coating manufacturing use in the "processing as a reactant" category. The original COU represented in the scope document, "incorporation into formulation, mixture, or reaction product," was included based on public comments. A commenter stated that manufacturers note residual amounts of 1,3-butadiene in architectural paints and coatings (EPA-HQ-OPPT-2018-0451-0005). However, "processing as a reactant – Intermediate in: paint and coating manufacturing" more accurately represent 1,3 butadiene's function in these uses.

- ***Industrial use – processing aids, specific to petroleum production – hydraulic fracturing fluids:*** Hydraulic Fracturing was added to the COU table in response to a public comment (EPA-HQ-OPPT-2019-0131-0036). The commenters stated that since 1,3-butadiene is listed in EPA's Hydraulic fracturing for oil and gas: Impacts from the hydraulic fracturing water cycle on drinking water resources in the United States, 1,3-butadiene should be included in the COU table in the scope. On checking the source from EPA's hydraulic fracturing report, FracFocus, 1,3-butadiene is not listed, instead a different chemical, Benzene, ethenyl-, polymer with 2-methyl-1,3-butadiene, hydrogenated (Chemical Abstracts Service Registry Number [CASRN] 68648-89-5) was listed in the report. The 2020 CDR data also did not report the use of 1,3-butadiene in hydraulic fracturing fluid. As a result, hydraulic fracturing was removed from the COU table.
- ***Consumer use; plastic and rubber products not covered elsewhere:*** EPA updated the table to reflect the most recent CDR reporting codes. These COUs are broken up into five subcategories: "Other articles with routine direct contact during normal use including rubber articles; plastic articles (hard);" "Toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard);" "Synthetic rubber (*e.g.*, rubber tires);" "Furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles;" and "Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft)." In addition, these COUs were reported in 2020 CDR as commercial use, but not all were reported as consumer use. However, EPA is assuming that if these products are in commercial use they could also be available for consumer use.

Appendix E CONDITIONS OF USE DESCRIPTIONS

The following descriptions are intended to include examples of uses so as not to exclude other activities that may also be included in the COUs of the chemical substance. To better describe the COU, EPA considered CDR submissions from the last two CDR cycles for 1,3-butadiene (CASRN 106-99-0) and the COU descriptions reflect what the Agency identified as the best fit for that submission. Examples of articles, products, or activities are included in the following descriptions to help describe the COU but are not exhaustive. EPA uses the terms "articles" and "products" or product mixtures in the following descriptions and is generally referring to articles and products as defined by 40 CFR part 751. There may be instances where the terms are used interchangeably by a company or commenters, or by EPA in reference to a code from the CDR reports, which are referenced; for example, "plastic products manufacturing," or "fabric, textile, and leather products." The Agency provides clarifications as needed when these references are included throughout the COU descriptions below.

E.1 Manufacturing – Domestic Manufacturing

Domestic manufacture means to produce 1,3-butadiene within the United States. For purposes of the 1,3-butadiene risk evaluation, this includes the extraction of 1,3-butadiene from a previously existing chemical substance or complex combination of chemical substances, and loading/unloading and repackaging (but not transport) associated with the manufacturing and production of 1,3-butadiene.

1,3-Butadiene can be produced by three processes: catalytic dehydrogenation of n-butane and n-butene, oxidative dehydrogenation of n-butene, and in the process of the steam cracking of hydrocarbon streams for ethylene production. The most common method is as a co-product during ethylene production (Sun and Wristers, 2002). The process can use a variety of hydrocarbon feedstocks, the heavier fractions generally giving a higher yield of 1,3-butadiene/amount of ethylene produced (Miller and Villaume, 1978).

Examples of CDR Submissions

In the 2016 CDR, nine companies reported domestic manufacturing of 1,3-butadiene with all manufacturers producing a liquid or a gas/vapor. In the 2020 CDR, eight companies reported importing of 1,3-butadiene with all manufacturers producing a liquid or a gas/vapor.

E.2 Manufacturing – Importing

Import refers to the import of 1,3-butadiene into the customs territory of the United States. This COU includes loading/unloading and repackaging (but not transport) associated with the import of 1,3-butadiene. In general, chemicals may be imported into the United States in bulk via water, air, land, and intermodal shipments. These shipments take the form of oceangoing chemical tankers, railcars, tank trucks, and intermodal tank containers (U.S. EPA, 2021b). 1,3-Butadiene is primarily shipped in pressurized containers via railroads or tankers (Sun and Wristers, 2002). Other forms of transport include pipeline and barge (National Toxicology Program (NTP), 1999).

Examples of CDR Submissions

In the 2016 CDR, nine companies reported importing of 1,3-butadiene with all importing a liquid or gas/vapor. In the 2020 CDR, nine companies reported importing of 1,3-butadiene with all importing a liquid or gas/vapor.

E.3 Processing – 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; and Paint and Coating Manufacturing

Processing as a reactant or intermediate is the use of 1,3-butadiene as a feedstock in the production of another chemical substance or product via a chemical reaction in which 1,3-butadiene is consumed to form the product, which is subsequently distributed in commerce. 1,3-Butadiene is used as a chemical intermediate in a variety of industry sectors including: adhesive manufacturing, fuel and propellant manufacturing, in petroleum refineries, fiber and textile manufacturing, rubber and plastic manufacturing, and other basic organic chemical manufacturing.

One use is in the production of Nylon. In this process, 1,3-butadiene is subjected to direct hydrocyanation to form pentenenitrile compounds and adiponitrile, which are further hydrogenated 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, which is 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).

Other examples of finished goods for which 1,3-butadiene is used in the upstream processes as a chemical intermediate included finish goods like rubber products, paints and coatings, flexographic printing plates, thermoplastic modification, electronics, encapsulants, wire and cable coatings, sealants, and adipic acid, conveyor belts, hoses, footwear, chloroprene for neoprene gloves, adiponitrile—which is converted to hexamethylenediamine for nylon, textiles, electronics, toys, adhesives, and products and articles used by the aerospace industry and defense (Boeing, ACD, AFPM). Commenters noted that 1,3-butadiene is not directly incorporated into these downstream products and articles, but that 1,3-butadiene is considered a "building block" block chemical primarily used as an upstream intermediate or precursor. This COU also includes activities identified by the U.S. Department of Defense (DOD). Interagency comments indicate that 1,3-butadiene is also processed as a reactant in propellant and solid rocket motor manufacturing, as well as other uses by the U.S. DOD.

Additionally, the National Library of Medicine's Hazardous Substance Databank (HSDB) 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 (NLM, 2003).

Examples of CDR Submissions

In the 2016 CDR, 13 companies reported processing as a reactant of 1,3-butadiene as an 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, and wholesale and retail trade. In the 2020 CDR, 10 companies for 1,3-butadiene reported processing as a reactant as an intermediate: for all other basic organic chemical manufacturing, organic fiber manufacturing, petrochemical manufacturing, petroleum refineries, plastic material and resin manufacturing, and synthetic rubber manufacturing. EPA is aware of one company reporting use of 1,3-butadiene as an "intermediate in non-incorporative activities: intermediate in wholesale and retail trade" in the 2020 CDR data. EPA is also aware that it was reported differently from the 2016 CDR data. However, based on EPA's understanding of 1,3-butadiene's use, the Agency is keeping this COU as a reactant rather than an intermediate in non-incorporative activities.

E.4 Processing – Reactant – Monomer Used in Polymerization Process in: Synthetic Rubber Manufacturing; Plastic Material and Resin Manufacturing

Processing as a reactant includes the polymerization of 1,3-butadiene with itself or with other monomers (Sun and Wristers, 2002). 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 (ABS), and nitrile rubber (Sun and Wristers, 2002). The general process at polymerization sites is unloading of 1,3-butadiene, a washing or purification step to remove polymerization inhibitors, then the different monomers are added to the reactor. After completion of reaction, the content of unreacted monomer may vary depending on the reactions and additives used. Typically, this may be followed with a butadiene monomer recovery system to recycle 1,3-butadiene back to feed into the reactor. Polymer production can be done either via emulsion polymerization or solution polymerization depending on the end product use. Once all monomers are depleted, 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). The final polymer products may be packaged for sale to downstream users (U.S. EPA, 1996). This polymerization product is incorporated into various downstream products and articles, which typically offers at a different site or facility than where the polymerization process occurs.

Examples of CDR Submissions

In the 2016 CDR, four companies reported processing as a reactant of 1,3-butadiene as a monomer used in polymerization process. In the 2020 CDR, six companies reported processing as a reactant of 1,3-butadiene as a monomer used in polymerization process. EPA is aware of one company reporting use of 1,3-butadiene as "Incorporation into a formulation, mixture, or reaction product – Monomers used in plastic product manufacturing; Synthetic rubber Manufacturing" in the 2020 CDR data. EPA is aware it was reported differently from the 2016 CDR data. However, based on EPA's understanding of 1,3-butadiene's chemical properties, EPA is keeping this COU as a reactant.

E.5 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Intermediate in: Petrochemical Manufacturing

This COU refers to the preparation of a product; that is, the incorporation into a formulation, mixture, or a reaction product which occurs when a chemical substance is added to a product (or product mixture) after its manufacture, for distribution in commerce. 1,3-Butadiene polymers are used in several petrochemical manufacturing operations (U.S. EPA, 2019a).

Examples of CDR Submissions

In the 2016 CDR, two companies reported use of 1,3-butadiene as a processing aid, not otherwise listed in petrochemical manufacturing. In the 2020 CDR, one company reported use of 1,3-butadiene as a processing aid, not otherwise listed in petrochemical manufacturing.

E.6 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Monomers in: Plastic Product Manufacturing; Plastic Material and Resin Manufacturing; and Synthetic Rubber Manufacturing

This COU refers to the preparation of a product; that is, the incorporation into a formulation, mixture, or a reaction product which occurs when a chemical substance is added to a product (or product mixture) after its manufacture, for distribution in commerce. The properties of 1,3-butadiene based polymers are affected by the molecular weight of the polymers. Desired properties of end-products or materials can be obtained by blending 1,3-butadiene based polymers of different molecular weights.

Examples of CDR Submissions

In the 2020 CDR, one company reported the use of 1,3-butadiene as a monomer in incorporation into a formulation in plastic and synthetic rubber manufacturing.

E.7 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Other: Oil and Gas Drilling, Extraction, and Support Activities)

This COU refers to the preparation of a product; that is, the incorporation of 1,3-butadiene into a formulation, mixture, or a reaction product, which occurs when a chemical substance is added to a product (or product mixture) after its manufacture, for distribution in commerce. 1,3-Butadiene is used as a processing aid and butadiene polymers are used in several petrochemical manufacturing operations, adhesives, lubricants and in formulated paints and coatings (EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0005; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT-2019-0131-0022).

Examples of CDR Submissions

In the 2024 CDR, one company reported the use of 1,3-butadiene in incorporation into a formulation for use in oil and gas drilling, extraction, and support activities.

E.8 Processing – Incorporation into a Formulation, Mixture, or Reaction Product – Plasticizer in: Asphalt Paving, Roofing, and Coating Material Manufacturing

This COU refers to the preparation of a product; that is, the incorporation of 1,3-butadiene into a formulation, mixture, or a reaction product, which occurs when a chemical substance is added to a product (or product mixture) after its manufacture, for distribution in commerce. 1,3-Butadiene is used to create dicarboxylic acid diisononyl ester, which is used in sensitive application areas to manufacture toys, children's products, medical devices, and food packaging when an alternative to phthalate plasticizers is needed.

Examples of CDR Submissions

In the 2024 CDR, one company reported the use of 1,3-butadiene in incorporation into a formulation for use as a plasticizer in asphalt paving, roofing, and coating material manufacturing.

E.9 Processing – Incorporation into Article – Monomer in: Rubber Product Manufacturing

This COU refers to the preparation of an article; that is, the incorporation of 1,3-butadiene into articles, meaning 1,3-butadiene becomes a component of the article, after its manufacture, for distribution in commerce. 1,3-Butadiene is used as a monomer or co-monomer in the manufacture of synthetic rubbers. These synthetic rubbers and latex are used to manufacture tires, other rubber components and plastic materials (U.S. EPA, 2019a). In plastic manufacturing, the final plastic article is produced in a conversion process that forms the compounded plastic into the finished products (U.S. EPA, 2014a; OECD, 2009). The converting process is different depending on whether the plastic is a thermoplastic or a thermosetting material (OECD, 2009). Thermoplastics converting involves the melting of the plastic material, forming it into a new shape and then cooling it (U.S. EPA, 2014a; OECD, 2009). The converting of thermoplastics may involve extrusion, injection molding, blow molding, rotational molding, or thermoforming (U.S. EPA, 2014a; OECD, 2009).

1,3-Butadiene is used in the manufacturing of different types of synthetic rubbers. The most common types of elastomers are styrene butadiene rubbers, acrylonitrile butadiene rubbers, butadiene rubbers, styrene isoprene butadiene rubbers, and styrene block copolymers (EPA-HQ-OPPT-2018-0451-0003). These rubbers are used in the manufacturing of many articles like tires, auto parts (*e.g.*, o-rings, molded parts, coatings), medical equipment (*e.g.*, tubes, surgical gloves, prosthetics), adhesives and sealants, rubber footwear, industrial goods (*e.g.*, rubber mats, hoses), and wire and cables (EPA-HQ-OPPT-2018-0451-0003). The IISRP states that residual 1,3-butadiene levels in synthetic rubber are "very low and depend on the type of synthetic rubber and the technology used in its manufacture, in most cases the level is not detectable."

Examples of CDR Submissions

In the 2016 CDR, one company reported incorporation into article – Other: Polymer in: Rubber and plastic product manufacturing. This use was not reported to the 2020 CDR reporting cycle.

E.10 Processing – Repackaging – Wholesale and Retail Trade Fuel; Synthetic Rubber Manufacturing; and Petrochemical Manufacturing

Repackaging refers to the preparation of 1,3-butadiene for distribution in commerce in a different form, state, or quantity than originally received or stored by various industrial sectors, including chemical product and preparation manufacturing, wholesale and retail trade, and laboratory chemicals manufacturing. This COU includes the transferring of 1,3-butadiene from a bulk container into smaller containers. Regarding this COU, one commenter (AFPM) stated that 1,3-butadiene is rarely repackaged into smaller containers because it is shipped as a liquid with a stabilizer to prevent polymerization. This COU would not apply to the relabeling or redistribution of a chemical substance without removing the chemical substance from the original container from which it was supplied.

Examples of CDR Submissions

This use was not reported to the 2016 CDR reporting cycle. In the 2020 CDR, one company reported repackaging 1,3-butadiene as an intermediate in wholesale and retail trade and another reported repackaging 1,3-butadiene as monomer in synthetic rubber manufacturing.

E.11 Processing – Use-Non-Incorporative Activities

This COU refers to the use of a chemical; that is, the use of 1,3-butadiene not involving intentionally adding it to a product, formulation, mixture, or article. 1,3-Butadiene may be used at industrial sites for fueling purposes.

Examples of CDR Submissions

In the 2020 CDR, one company reported the use of 1,3-butadiene for non-incorporative activities.

E.12 Processing – Recycling

This COU refers to the process of treating generated waste streams (*i.e.*, which would otherwise be disposed of as waste), containing 1,3-butadiene that are collected, either on-site or transported to a third-party site, for commercial purpose. Recovery and recycling of unreacted 1,3-butadiene from the various synthetic rubber manufacturing operations are common. 1,3-Butadiene and other monomers (such as styrene) are recovered and reused in rubber manufacturing to the extent possible (ECB, 2002). EPA notes that although 1,3-butadiene was not reported for recycling in the 2016 or 2020 CDR reporting periods, the Agency is assuming that recycling waste streams could contain 1,3-butadiene.

There are multiple ways 1,3-butadiene can be recycled during its life cycle. 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.

E.13 Distribution in Commerce

For purposes of assessment in this risk evaluation, distribution in commerce consists of the transportation associated with the moving of 1,3-butadiene or 1,3-butadiene-containing products between sites manufacturing, processing, or recycling 1,3-butadiene or 1,3-butadiene-containing products; and final use sites for final disposal of 1,3-butadiene or 1,3-butadiene-containing products. More broadly under TSCA, "distribution in commerce" and "distribute in commerce" are defined under TSCA section 3(5).

E.14 Industrial Use – Adhesives and Sealants, Including Epoxy Resins

This COU refers to 1,3-butadiene as it is used in various industrial sectors as a component of adhesive or sealant mixtures. Examples of applications for adhesive and sealant products that are used in aerospace industrial uses include adhesives critical to electrical and circuit boards and pre-impregnated fiberglass or carbon reinforced fabrics and tapes, as well as epoxy resin adhesive systems for bonding and sealing of glass to metal components (EPA-HQ-OPPT-2018-0451-0009).

EPA has identified two safety data sheets (SDSs) associated with tire patch repair kits where 1,3-butadiene is listed in concentrations well above de minimis or residual values. However, EPA did not include these as supporting references for the 1,3-butadiene COUs (listed in Table 2-1). Based on EPA's understanding of 1,3-butadiene's use in the manufacturing of rubber polymers and adhesives and sealants, as supported by numerous public commenters, 1,3-butadiene monomer is not present at these concentrations in commercial and consumer products; that is, the SDSs are likely referring to a 1,3-butadiene polymer.

Boeing stated that while potting compounds encapsulate and protect electronic components from environmental factors, casting compounds create solid objects or parts by pouring the compound into a mold. Although potting and casting compounds provide sealing and protective functions similar to sealants, they have distinct purposes and application methods tailored to their specific applications. Consequently, these applications do not fit neatly within EPA's current COU definitions. Boeing requested that EPA clarify this, which the Agency has done by including these descriptors in the Adhesives and sealants COU.

Examples of CDR Submissions
In the 2016 CDR, one company reported use of 1,3-butadiene as an intermediate in adhesive manufacturing. This use was not reported to the 2020 CDR reporting cycle.

E.15 Commercial Use – Fuels and Related Products – Fuel Additive; Vehicular or Appliance Fuels; Cooking and Heating Fuels

This COU is referring to the commercial use of 1,3-butadiene in fuels and related products. 1,3 Butadiene is a byproduct in the refining process and in liquified petroleum gas (LPG) as a result of butane contamination. 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. Evidence was found however, of 1,3-butadiene's presence within butane 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." LPG can be used for the same domestic, commercial, and industrial applications as natural gas; the largest market for LPG is the domestic/commercial market. Furthermore, 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 also 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 vs. smaller cylinders for consumer cooking).

Examples of CDR Submissions
In the 2016 CDR, one company reported use of 1,3-butadiene as commercial use in fuels and related products. In the 2020 CDR, one company reported the use of 1,3-butadiene as sold to re-sellers for petroleum fuel and petrochemical industry.

E.16 Commercial Use – Other Articles with Routine Direct Contact During Normal Use Including Rubber Articles; Plastic Articles (Hard); Toys Intended For Children's Use (and Child Dedicated Articles), Including Fabrics, Textiles, and Apparel; or Plastic Articles (Hard); Synthetic Rubber (*e.g.*, Rubber Tires); Furniture & Furnishings Including Stone, Plaster, Cement, Glass and Ceramic Articles; Metal Articles; or Rubber Articles; and Packaging (Excluding Food Packaging), Including Rubber Articles; Plastic Articles (Hard); Plastic Articles (Soft)

This COU is referring to the commercial use of 1,3-butadiene already incorporated in plastic and rubber products not covered elsewhere. EPA understands examples of this COU could include tires, auto parts, the medical industry, footwear, industrial goods, the construction industry, appliances, lubricants, fabrics, wires and cables, as well as synthetic rubber in toys (EPA-HQ-OPPT-2018-0451-0003, EPA-HQ-OPPT-2019-0131-0012).

"The nuclear industry uses materials made from 1,3 butadiene including polychloroprene (neoprene), nitrile rubber (NR), styrene-butadiene rubber (SBR), and in limited applications polybutadiene rubber (PBR) equipment that is needed to ensure the safety of the reactors under normal and abnormal conditions. These materials are used primarily in sealing applications such as gaskets, o-rings and some limited applications in bushings to address piping vibration and v-belt applications at nuclear power plants."

Examples of CDR Submissions

In the 2016 CDR, four companies reported commercial use of 1,3-butadiene in plastic and rubber products not covered elsewhere. After updates to the 2020 CDR reporting cycle, the subcategories changed from the 2016 CDR reporting cycle. In the 2020 CDR, (1) three companies reported commercial use of 1,3-butadiene as other articles with routine direct contact during normal use, including rubber articles; plastic articles (hard); (2) one company reported commercial use of 1,3-butadiene in toys intended for children's use (and child dedicated articles), including fabrics, textiles, and apparel; or plastic articles (hard); (3) one company reported commercial use of 1,3-butadiene in synthetic rubber (*e.g.*, rubber tires); (4) one company reported commercial use of 1,3-butadiene in furniture & furnishings including stone, plaster, cement, glass and ceramic articles; metal articles; or rubber articles; and (5) one company reported commercial use of 1,3-butadiene in packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft).

E.17 Commercial Use – Other Use – Laboratory Chemicals

This COU is referring to the commercial use of 1,3-butadiene in laboratory chemicals. EPA understands 1,3-butadiene could be used as a product in analytical chemistry, research, equipment calibration, and sample preparation applications, including reference sample for analysis of terrestrial and extraterrestrial material samples. Additionally, 1,3-butadiene could be as a component of resin products that are used in research (EPA-HQ-OPPT-2018-0451-0039).

This use was not reported to EPA in the 2016 or 2020 CDR reporting cycles.

E.18 Commercial Use – Lubricants and Lubricant Additives

This COU is referring to the commercial use of 1,3-butadiene based polymers in lubricants and lubricant additives, including for use as lubricant additives and viscosity modifiers (EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2019-0131-0022)

This use was not reported to EPA in the 2016 or 2020 CDR reporting cycles.

E.19 Commercial Use – Paint and Coatings

This COU is referring to the commercial use of 1,3-butadiene in paints and coatings. EPA understands 1,3-butadiene to be present in architectural paints and coatings (EPA-HQ-OPPT-2018-0451-0005).

This use was not reported to EPA in the 2016 nor 2020 CDR reporting cycles.

E.20 Commercial Use – Adhesives and Sealants

This COU is referring to the commercial use of 1,3-butadiene in adhesives and sealants, including epoxy resins (EPA-HQ-OPPT-2018-0451-0003; EPA-HQ-OPPT-2018-0451-0009; EPA-HQ-OPPT- 2019-0131-0022).

This use was not reported to EPA in the 2016 nor 2020 CDR reporting cycles.

E.21 Consumer Use – Other Articles with Routine Direct Contact During Normal Use Including Rubber Articles; Plastic Articles (Hard); Toys Intended for Children's Use (and Child Dedicated Articles), Including Fabrics, Textiles, and Apparel; or Plastic Articles (Hard); Synthetic Rubber (*e.g.*, Rubber Tires); Furniture & Furnishings Including Stone, Plaster, Cement, Glass and Ceramic Articles; Metal Articles; or Rubber Articles; and Packaging (Excluding Food Packaging), Including Rubber Articles; Plastic Articles (Hard); Plastic Articles (Soft)

This COU is referring to the consumer use of plastic rubber products, including rubber tires. 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).

Examples of CDR Submission

In the 2016 CDR, two companies reported consumer use of 1,3-butadiene in plastic and rubber products not covered elsewhere. This use was not reported to the 2020 CDR reporting cycle.

E.22 Disposal

Each of the COUs of 1,3-butadiene may generate waste streams of the chemical. For purposes of the 1,3-butadiene risk evaluation, this COU refers to the 1,3-butadiene in a waste stream that is collected from facilities and households and are unloaded at and treated or disposed at third-party sites. This COU also encompasses 1,3-butadiene contained in wastewater or other wastes generated by consumer or occupational users and discharged to a publicly owned treatment works (POTW) or other, non-public treatment works. TRI data indicate 1,3-butadiene may be land disposed, deep-well injected, or discharged to water following pretreatment (U.S. EPA, 2019c). Disposal may also include destruction and removal by incineration. Streams containing 1,3-butadiene may be combined with crude streams for energy recovery when finished 1,3-butadiene does not meet commercial specifications. Recycling of 1,3-butadiene and 1,3-butadiene-containing products is considered a different COU. Environmental releases from industrial sites are assessed in each COU.

Appendix F OCCUPATIONAL EXPOSURE VALUE DERIVATION AND ANALYTICAL METHODS USED TO DETECT 1,3-BUTADIENE

EPA has calculated an 8-hour TWA existing chemical occupational exposure value to summarize the occupational exposure scenario (OES) and sensitive health endpoints into a single value. This calculated value may be used to support risk management efforts for 1,3-butadiene under TSCA section 6(a), 15 U.S.C. 2605. EPA calculated the value rounded to 0.11 ppm (0.24 mg/m^3) for inhalation exposures to 1,3-butadiene as an 8-hour TWA and for consideration in workplace settings (see Appendix F.1 below) based on the chronic occupational unit risk (UR) for cancer (combined risk from leukemia and bladder cancer).

TSCA requires risk evaluations to be conducted without consideration of cost and other nonrisk factors; therefore, this most sensitive occupational exposure value represents a risk-only number. If risk management for 1,3-butadiene is implemented following the final risk evaluation, EPA may consider cost and other nonrisk factors such as technological feasibility, the availability of alternatives, and the potential for critical or essential uses. Any existing chemical exposure limit (ECEL) used for occupational safety risk management purposes could differ from the occupational exposure value presented in this appendix based on additional consideration of exposures and nonrisk factors consistent with TSCA section 6(c).

This calculated value for 1,3-butadiene represents the exposure concentration below which exposed workers and occupational non-users (ONUs) are not expected to exhibit any appreciable risk of adverse toxicological outcomes. This value accounts for potentially exposed or susceptible subpopulations (PESS). The value is derived based on the most sensitive human health effect (*i.e.*, cancer) supported by the weight of scientific evidence. This value is expressed relative to benchmarks and standard occupational scenario assumptions of 8 hours per day, 5 days per week exposures for a total of 250 days exposure per year, and a 40-year working life.

All hazard values used in these calculations are based on the non-cancer intermediate point of departure (POD) and chronic occupational cancer UR from the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y).

EPA expects that at the occupational exposure value of 0.11 ppm (0.24 mg/m^3) for lifetime exposure, workers and ONUs also would be protected against non-cancer health effects for acute, intermediate, and chronic durations. EPA has not separately calculated a short-term occupational exposure value (STEV) for 1,3-butadiene (see Section F.3 for details).

Of the identified occupational monitoring data for 1,3-butadiene, there have been measured workplace air concentrations below the calculated exposure value. A summary table (Table_Apx F-1) of available monitoring methods from OSHA and the National Institute for Occupational Safety and Health (NIOSH) is included in Appendix F.2. The table presents validated methods from governmental agencies and is not intended to be a comprehensive list of available air monitoring methods for 1,3-butadiene. The calculated occupational exposure value is above the limit of detection (LOD) and limit of quantification (LOQ) using at least one of the monitoring methods identified.

OSHA has set a PEL (accessed December, 5, 2025) as an 8-hour TWA for 1,3-butadiene of 1 ppm and a STEL of 5 ppm at a duration of 15 minutes. However, as noted on OSHA's website, "OSHA recognizes that many of its PELs are outdated and inadequate for ensuring protection of worker health. Most of

OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health (OSH) Act in 1970 and have not been updated since that time." In addition, OSHA's PEL must undergo both risk assessment and feasibility assessment analyses before selecting a level that will substantially reduce risk under the OSH Act. EPA's calculated exposure value is a lower value and is based on newer information and analysis from this risk evaluation.

Other governmental agencies and independent groups have also set recommended exposure limits established for 1,3-butadiene. The American Conference of Governmental Industrial Hygienists (ACGIH) has set a Threshold Limit Value (TLV) at 2 ppm TWA. While this chemical does not have a NIOSH Recommended Exposure Limit (REL), NIOSH notes and identifies 1,3-butadiene as a carcinogen and lists the following guidance: "reduce exposures to lowest feasible concentrations".

F.1 Occupational Exposure Value Calculations

This section presents the calculations used to estimate the occupational exposure values (OEVs) using inputs derived in this risk evaluation. Multiple values are presented below for hazard endpoints based on different exposure durations. For 1,3-butadiene, the most sensitive OEV is based on cancer following lifetime exposure and the resulting 8-hour TWA is rounded to 0.11 ppm. The human health hazard values (human equivalent concentrations [HECs], UR) used in the equations are derived in the risk evaluation and discussed in the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y).

Most Sensitive Occupational Exposure Value (Lifetime Cancer)

The EV_{cancer} is the concentration at which the extra cancer risk is equivalent to the benchmark cancer risk of $1{\times}10^{-4}$. The adjustments to exposure averaging time corresponds to the updated lifetable for cancer, which assumed up to 62 years of exposure for the occupational cohort (*i.e.*, no exposure during the first 16 years of life). Therefore, the cancer OEV and all risk calculations use 62 years for lifetime average daily concentration instead of the typical 78 (because this reduced window of relevant exposure years has already been accounted for).

$$EV_{cancer} = \frac{Benchmark_{Cancer}}{UR} * \frac{AT_{IUR}}{ED*EF*WY} * \frac{\mathrm{IR_{resting}}}{\mathrm{IR_{workers}}} = \frac{1X10^{-4}}{6.44{\times}10^{-3}\ per\ ppm} * \frac{24\frac{h}{d}*\frac{365d}{y}*62y}{8\frac{h}{d}*\frac{250d}{y}*40y} * \frac{1.25\frac{\mathrm{m}^3}{hr}}{1.25\frac{\mathrm{m}^3}{hr}} = 0.11\ \mathrm{ppm}$$

$$\mathrm{EV_{cancer}}\left(\frac{\mathrm{mg}}{\mathrm{m}^3}\right) = \frac{EV\ ppm*MW}{Molar\ Volume} = \frac{0.11\ \mathrm{ppm}*54.0916\frac{g}{mol}}{24.45\ \frac{L}{mol}} = 0.24\ \frac{\mathrm{mg}}{\mathrm{m}^3}$$

Where:

Molar Volume	=	24.45 L/mol, the volume of a mole of gas at 1 atm and 25 °C
MW	=	Molecular weight of 1,3-butadiene (54.0916 g/mole)

Acute Non-Cancer Occupational Exposure Value

EPA did not derive an acute POD for 1,3-butadiene. Therefore, no corresponding OEV is calculated.

Intermediate Non-Cancer Occupational Exposure Value

The intermediate occupational exposure value ($EV_{intermediate}$) was calculated as the concentration at which the intermediate margin of exposure (MOE) would equal the benchmark MOE for intermediate occupational exposure using the following equation:

$$\mathrm{EV}_{\mathrm{intermediate}} = \frac{\mathrm{HEC}_{\mathrm{intermediate}}}{Benchmark\ MOE_{intermediate}} * \frac{\mathrm{AT}_{\mathrm{HEC\ intermediate}}}{ED * EF} * \frac{\mathrm{IR}_{\mathrm{resting}}}{\mathrm{IR}_{\mathrm{workers}}}$$

$$= \frac{2.5\ \mathrm{ppm}}{30} * \frac{24h/d * 30d}{8h/d * 22d} * \frac{0.6125\ \mathrm{m}^3/hr}{1.25\ \mathrm{m}^3/hr} = 0.17\ \mathrm{ppm}$$

$$\mathrm{EV}_{\mathrm{intermediate}}\left(\frac{\mathrm{mg}}{\mathrm{m}^3}\right) = \frac{EV\ ppm * MW}{Molar\ Volume} = \frac{0.17\ \mathrm{ppm} * 54.0916 \frac{g}{mol}}{24.45 \frac{L}{mol}} = 0.38\ \frac{\mathrm{mg}}{\mathrm{m}^3}$$

Chronic Non-Cancer Occupational Exposure Value

The hazard value (an HEC of 2.5 ppm) is the same for the intermediate and chronic OESs. The chronic occupational exposure value ($\mathrm{EV}_{\mathrm{chronic}}$) can be calculated as the concentration at which the chronic MOE would equal the benchmark MOE for exposures. However, EPA has determined that because the same critical health effect applies to both intermediate and chronic exposure contexts, the relevant averaging time should be considered equivalent across both exposure scenarios. Therefore, the resulting $\mathrm{EV}_{\mathrm{chronic}}$ would be the same as the $\mathrm{EV}_{\mathrm{intermediate}}$ based on intermediate exposures and EPA is presenting only the $\mathrm{EV}_{\mathrm{intermediate}}$.

The parameters used in the above equations are described herein. Numerical values chosen for the parameters are described in relevant sections of this risk evaluation and the *Human Health Hazard Assessment for 1,3-Butadiene* (U.S. EPA, 2025y).

Where:

$AT_{HECintermediate}$	=	Averaging time for the POD/HEC used for evaluating non-cancer, intermediate occupational risk, based on study conditions and/or any HEC adjustments (24 hours/day for 30 days)
AT_{UR}	=	Averaging time for the cancer UR, based on study conditions and any adjustments (24 hours/day for 365 days/year) and averaged over a lifetime (78 years)
$Benchmark\ MOE_{intermediate}$	=	Intermediate non-cancer benchmark margin of exposure, based on the total uncertainty factor of 30
$\mathrm{Benchmark}_{\mathrm{cancer}}$	=	Benchmark for excess lifetime cancer risk
$EV_{intermediate}$	=	Occupational exposure value based on reduced fetal body weight
$EV_{chronic}$	=	Occupational exposure value based on reduced fetal body weight
EV_{cancer}	=	Occupational exposure value based on excess cancer risk
ED	=	Exposure duration (8 hours/day)
EF	=	Exposure frequency 22 days/year for intermediate, 250 days/year for lifetime
$HEC_{intermediate}$	=	Human equivalent concentration for acute, intermediate, or chronic occupational exposure scenarios
UR	=	Occupational unit risk (per $\mathrm{mg/m}^3$ and per ppm)
IR	=	Inhalation rate (default is 1.25 m^3/h for workers and 0.6125 m^3/h for the general population at rest)
WY	=	Working years per lifetime at the 95th percentile (40 years)
Molar Volume	=	24.45 L/mol, the volume of a mole of gas at 1 atm and 25 °C
MW	=	Molecular weight of 1,3-butadiene (54.0916 g/mole)

Unit conversion:
1 ppm = 2.2 mg/m^3 (based on the molecular weight of 54.0916 g/mol for 1,3-butadiene)

F.2 Summary of Air Sampling Analytical Methods Identified

EPA conducted a search to identify relevant NIOSH, OSHA, and EPA analytical methods used to monitor for the presence of 1,3-butadiene in air (see Table_Apx F-1). This table presents validated methods from governmental agencies and is not intended to be a comprehensive list of available air monitoring methods for 1,3-butadiene. The sources used for the search included the following:

1) NIOSH Manual of Analytical Methods (NMAM); 5th Edition
   - URL: https://www.cdc.gov/niosh/nmam/default.html, (accessed December 5, 2025)
2) NIOSH NMAM 4th Edition
   - URL: https://www.cdc.gov/niosh/docs/2003-154/default.html, (accessed December 5, 2025)
3) OSHA Index of Sampling and Analytical Methods
   - URL: https://www.osha.gov/dts/sltc/methods/, (accessed December 5, 2025)
4) EPA Environmental Test Method and Monitoring Information
   - URL: https://www.epa.gov/measurements-modeling/index-epa-test-methods, (accessed December 5, 2025)

Table_Apx F-1. Limit of Detection (LOD) and Limit of Quantification (LOQ) Summary for Air Sampling Analytical Methods Identified

Air Sampling Analytical Methods	Year Published	LOD[a]	LOQ	Notes	Source
NIOSH Method 1024 [b]	1994 (issue 2)	As low as 0.2 µg/sample (3.6 ppb) [c]	N/A[d]	NIOSH Method 1024 reports the LOD as 0.2 µg per sample and provides procedures for collecting air samples between 5 and 25 L with a flow rate of 0.01 to 0.5 L/min. Multiple media change-outs will be required in order to achieve the minimum LOD based on a maximum sampling volume of 25 L.	NIOSH NMAM 4th Edition
OSHA Method 56		0.6 µg/sample (90 ppb)	N/A	OSHA Method 56 recommends an air sample volume of 3 L.	OSHA Index of Sampling and Analytical Methods
EPA Method TO-17	1999	≈0.1 ppb	N/A	Thermally desorbable cartridges attached to pumps. LOD calculated based on a flow rate of 1 mL/min for 480 minutes and volume-based adjustment of the detection limit for a 2,000 mL sample.	EPA TO-17 sampling recommendations EPA TO-17 detection limits

All hyperlinks in this table were last accessed on December 5, 2025.
ppm = parts per million; ppb = parts per billion; ppt = parts per trillion
[a] These sources cover a range of LODs both below and above the most sensitive OEV. This method provides the LOD based on sample size. For a sample size range of 0.5L to 15L, the LOD would be 0.67 mg/m^3 to 20 mg/m^3. However, the LOD listed in the table can be achieved through changes of media across an 8-hour period.
[b] It is common for laboratories to acquire updated equipment from the equipment used by NIOSH to develop Method 1003. Modern equipment can offer dramatically greater performance compared with the equipment available when NIOSH 1003 was published. This can result in significantly lower LOQ/LODs. However, NIOSH does not necessarily continually update the method because the labs are using the same general procedures with just modified/better

Air Sampling Analytical Methods	Year Published	LOD[a]	LOQ	Notes	Source
equipment. Therefore, the lab is permitted to report their method as "modified NIOSH Method 1003". The lab will include a record of how it modifies the method in their results. [c] This LOD is likely an underestimate or would have limited accuracy at that concentration. The "Applicability" statement for the method states that below 400 ppb "the desorption efficiency falls below 75% and allowance should be made for decreased accuracy. The "working range" for the method is less than the mass of target substance, and it may be unreasonable to expect a full 480-minute sample. [d] When an LOQ is not calculated, in the absence of methods-specific information it can be assumed to be 3x the LOD value.					

F.3 Short-Term Occupational Exposure Value Derivation

According to *Current Intelligence Bulletin 69: NIOSH Practices in Occupational Risk Assessment* (NIOSH, 2020) (accessed December 5, 2025), a short-term OEV (described as a STEL) in (NIOSH, 2020) (accessed December 5, 2025) should be derived if there is a concern for effects following short-term exposure at 15-min concentrations. The 8-hour TWA most sensitive OEV would prevent 15-min exposures above 32× that value (based on 32 15-minute periods in 8 hours), assuming only a single 15-minute chemical exposure in 1 day. Therefore, if short-term health effects are expected and can be quantified with a derived short-term occupational exposure value (STEV) lower than 32× the most sensitive exposure value (EV)—implementing a short-term exposure value could be justified.

EPA did not derive an acute non-cancer hazard value for 1,3-butadiene because any options would have low confidence and be less protective than existing exposure limits. Therefore, EPA would default to the Acute Exposure Guideline Level-1 (AEGL) value for determination of a STEV. The AEGL-1 value for 1,3-butadiene based on difficulty to focus is 670 ppm (NAC/AEGL, 2009). This value is significantly higher than the 15-min TWA occupational exposure equivalent value (Table_Apx F-2); therefore, the most sensitive OEV is already protective of any hazards specific to short-term exposure.

Table_Apx F-2. Comparison Between Occupational Exposure Values for 1,3-Butadiene

Value Type	Most Sensitive Occupational Exposure Value (8-hour TWA)	Possible Short-term Occupational Exposure Value (15-minute value)	Most Sensitive Occupational Exposure Value (15-minute TWA)
Health Effect	Cancer	Difficulty to focus	Cancer
Exposure Value (ppm)	0.11	670	3.5

Appendix G POTENTIALLY EXPOSED OR SUSCEPTIBLE SUBPOPULATIONS CONSIDERED IN RISK EVALUATIONS

Considerations related to PESS can influence the selection of relevant exposure pathways, the sensitivity of derived hazard values, the inclusion of particular human populations, and the discussion of uncertainties throughout the assessment. Evaluation of the qualitative and quantitative evidence for PESS begins as part of the systematic review process, where any available relevant published studies and other data are identified. If adequate and complete, this evidence informs the derivation of exposure estimates and human health hazard endpoints/values that are protective of PESS.

EPA has identified a list of specific PESS factors that may contribute to a group having increased exposure or biological susceptibility, such as life stage, occupational exposures, nutrition, and lifestyle activities. For 1,3-butadiene, the Agency identified how the risk evaluation addressed these factors as well as any remaining uncertainties in Section 2.2.4 The full list of PESS factors and representative examples of each are presented below in Table_Apx G-1.

Table_Apx G-1. PESS Factors Considered in the Risk Evaluation

PESS Factor	Examples[a]
Life stage	Embryo/fetus, pregnant females, children, older adults
Pre-existing disease	Obesity, cardiovascular disease, diabetes
Lifestyle activities	Smoking, alcohol consumption, physical activity
Occupational exposures	High-end duration and frequency workers/ONUs
Geography/site-specific	Fenceline, residence/school location, historical releases
Sociodemographic status	Race/ethnicity, socioeconomic status, sex/gender, education
Nutrition	Diet, malnutrition, subsistence fishing
Genetics/epigenetics	Genetic polymorphisms
Unique activities	Open burning, sweat lodge/purification ceremonies (Tribal)
Aggregate exposures	Multiple routes, multiple pathways, multiple COUs
Other chemical and non-chemical stressors	Stress, adverse childhood experiences, built environment, chemical co-exposures

[a] Examples are not intended to be exhaustive but are illustrative of considerations for the risk evaluation.

Appendix H GENERAL POPULATION RISK CHARACTERIZATION

H.1 HEM Model Inputs with NEI Data

H.1.1 Introduction

EPA used release data from the Agency's National Emissions Inventory (NEI), with EPA's Human Exposure Model (HEM), to estimate air concentrations resulting from air releases of 1,3-butadiene modeled at census block receptors and co-located receptors surrounding the release sources. Because the setup of these model runs is generally the same as described in the *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u) for the TRI dataset, EPA focuses these sections on those areas where the setup using the NEI dataset differed.

H.1.2 HEM

HEM 5.0 has two components: (1) an atmospheric dispersion model, AERMOD[7], with included meteorological data; and (2) U.S. Census Bureau population data at the block level. The current HEM version utilizes 2020 Census data—including all 50 states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands.[8] AERMOD estimates the magnitude and distribution of chemicals concentrations in ambient air in the vicinity of each releasing facility within a user-defined radial distances out to 50 kilometers (km; ≈30 miles). HEM provides chemical concentrations in ambient air at the centroid of over 8 million census blocks across the United States. HEM is able to combine the estimated chemical concentrations with dose-response data to estimate cancer risks and non-cancer hazards, the population data to inform cancer incidence, and other risk measures. HEM automatically utilizes meteorological data for each release point, as well as local topographic information, to inform the release dispersion model. Refer to the HEM 5.0 User Guide[9] for more details about these and other capabilities.

H.1.3 Model Settings

Most of the HEM model settings for using the NEI dataset are identical to those described in the previous section for TRI (see *General Population Exposures for 1,3-Butadiene* (U.S. EPA, 2025u)). However, the NEI dataset has some additional information or unique information and therefore this section describes only those unique aspects associated with the NEI dataset.

EPA used NEI reported release data from reporting years 2017 and 2020 to populate the HAP emissions file which in turn are used as direct inputs to the HEM model. These release data are described and provided in the *Environmental Releases and Occupational Exposure Assessment for 1,3-Butadiene* (U.S. EPA, 2025r) and includes (among others) facility names, locations, identifier codes, OES assignments, and annual air releases (stratified by fugitive and point sources).

EPA modeled each year of NEI reported releases separately. This ensured that any multi-facility aggregate outputs that HEM produced per run were confined to release data from the same year.

[7] Page for AERMOD (American Meteorological Society/Environmental Protection Agency Regulatory Model): https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models#aermod, (accessed December 5, 2025).

[8] The HEM census file for the U.S. Virgin Islands has 0 people in each location. Block-level population data may not be currently available from the 2020 census.

[9] HEM 5.0 User Guide: https://www.epa.gov/system/files/documents/2025-05/hem5.0-users-guide.pdf (accessed December 8, 2025)

Table_Apx H-1 summarizes the values and settings used in the HEM "facility list" input file, and Table_Apx H-2 through Table_Apx H-6 provide additional information on those values and settings.

HEM calculated risks using a cancer unit risk estimate (IUR) of 5.83×10^{-6} $(\mu g/m^3)^{-1}$ and a chronic non-cancer reference concentration (RfC) of 0.183 mg/m^3 for reproductive hazards.

Table_Apx H-1. Settings for HEM's "Facility List" Input File

Parameter Group	Parameter	Value or Setting	Interpretation	Notes
Dispersion Environment	met_station	[blank]	Model chose the meteorology station closest to each facility	
	rural_urban	[blank]	Model found the nearest census block to the facility center and determined whether that block was located in an urbanized area as designated by the 2020 Census	
	urban_pop	[blank]	Model used a default of 50,000 people for the urban population	
Modeling Domain Defined	max_dist	50,001	Model used a default of 50,000 meters to define the modeling domain around each facility (entering 50,001 here forced a default of 50,000)	
	model_dist	51,001	Model used a default of 3,000 meters to define the cutoff distance around each facility for explicitly modeling census block receptors, and then any block receptors beyond that had their modeling results interpolated from polar receptors (entering 51,001 here forced a default of 3,000)	For a small number of facilities, there were no populated block centroids within 3,000 m of the facility, and this distance was set to a value slightly larger than the value needed to include a populated block centroid (see Table_Apx H-2)
	radials	16	Model used polar receptors at the default of 16 radials	
	circles	11	Model used polar receptors at 11 concentric rings	
	overlap_dist	30	Model used a default 30 m to define the facility fence line, inside which receptors were not considered as a point of maximum exposure/risk	
	ring1	10	Model used 10 m for the distance of the first ring of polar receptors	

Parameter Group	Parameter	Value or Setting	Interpretation	Notes
Modeling Domain Defined *(continued)*	fac_center	L, [custom for each facility: latitude, longitude]	Model used a facility latitude and longitude which we calculated as the average of all the facility's source coordinates being modeled	
	ring_dists	10, 30, 60, 100, 1,000, 2,500, 5,000, 10,000, 15,000, 25,000, 50,000	Model used concentric rings of polar receptors at these distances (in meters)	
Acute Options	acute	Y	Model calculated short-term concentrations	
	hours	24	Model defined "short term" as 24 hours (*i.e.*, daily)	
	multiplier	1	Model used the hourly emissions as-is, without multiplying them by a factor that would approximate short-term emission rates above baseline	
	high_value	18	Model reports the 18th-highest acute concentration at each receptor (this approximates the 95th-percentile daily concentration)	
Deposition and Depletion Parameters	dep	[blank]	Model did not estimate deposition	
	depl	[blank]		
	pdep	[blank]		
	pdepl	[blank]		
	vdep	[blank]		
	vdepl	[blank]		
Additional Options	elev	Y	Model included the elevation of receptors in the concentration estimates, using HEM's "online" method of acquiring terrain elevation data	
	flagpole	Y, 1	Model included receptor heights of 1 meter as a proxy for a child's breathing height	

Parameter Group	Parameter	Value or Setting	Interpretation	Notes
Additional Options *(continued)*	user_rcpt	Y	Model used additional user-specified receptors (beyond the polar grid and census blocks)—*i.e.*, the grids at 30–60 m and 100–1,000 m from the facility	
	bldg_dw	N	Model did not estimate building downwash, which is the default choice	
	fastall	Y	Model used AERMOD's FASTALL option to conserve model run time by simplifying the dispersion algorithms, which is not the default choice	
	emiss_var	Y	Model used time-varying emissions, specified in a separate file	Separate file used AERMOD's MHRDOW7 format allowing emission rates to vary by month, hour of day, and the seven days of the week (Table_Apx H-3 and Table_**Apx H-4**)
	annual	Y	Model used the default setting to calculate an annual average as a long-term concentration, which is the default choice	
	period_start	[blank]		
	period_end	[blank]		

Table_Apx H-2. Substitutions Made for the Facility List File's "model_dist" Parameter

FacilityID	"model_dist" (m)	
	2017	2020
5632411	4,683	4,671
Note: The values were slightly different between inventory years due to slight differences in facility coordinates.		

Table_Apx H-3. Assumptions for Intraday Emission-Release Duration

Hours per Day of Emissions from EPA	Assumed Hours of the Day Emitting for Modeling
0.1, 1	1: Hour 13 (hour ending at 1 pm; *i.e.*, 12–1 pm)
2	2: Hours 13–14 (hour ending at 1 pm through hour ending at 2 pm; *i.e.*, 12–2 pm)
4	4: Hours 13–16 (hour ending at 1 pm through hour ending at 4 pm; *i.e.*, 12–4 pm)
5	5: Hours 13–17 (hour ending at 1 pm through hour ending at 5 pm; *i.e.*, 12–5 pm)
5.7	6: Hours 12–17 (hour ending at 12 pm through hour ending at 5 pm; *i.e.*, 11 am to 5 pm)
8	8: Hours 9–16 (hour ending at 9 am through hour ending at 4 pm; *i.e.*, 8 am to 4 pm)
9	9: Hours 9–17 (hour ending at 9 am through hour ending at 5 pm; *i.e.*, 8 am to 5 pm)
10	10: Hours 9–18 (hour ending at 9 am through hour ending at 6 pm; *i.e.*, 8 am to 6 pm)
11.2	11: Hours 9–19 (hour ending at 9 am through hour ending at 7 pm; *i.e.*, 8 am to 7 pm)
15	15: Hours 6–20 (hour ending at 6 am through hour ending at 8 pm; *i.e.*, 5 am to 8 pm)
16, 16.5	16: Hours 6–21 (hour ending at 6 am through hour ending at 9 pm; *i.e.*, 5 am to 9 pm)
18	18: Hours 5–22 (hour ending at 5 am through hour ending at 10 pm; *i.e.*, 4 am to 10 pm)
20, 20.4	20: Hours 4–23 (hour ending at 4 am through hour ending at 11 pm; *i.e.*, 3 am to 11 pm)
24	All hours

Table_Apx H-4. Assumptions for Inter-Day Emission-Release Pattern

Days per Year of Emissions from EPA	Assumed Days of the Year Emitting for Modeling		
	Which Days	Number of Days per Year	Emission Factor When Emissions On (24 hours/day)
250	All Mondays to Thursdays, and Fridays in January to September	247 (in 2017), 249 (in 2020)	1.474
300	All Mondays to Fridays, and Saturdays in January to September	299 (in 2017), 301 (in 2020)	1.219
350	All Mondays to Saturdays, and Sundays in January to August	347 (in 2017), 349 (in 2020)	1.051
364, 365, 366	All days	365 (in 2017), 366 (in 2020)	1

Table_Apx H-5. Physical Source Specifications

Parameter	Bounds	Condition			
		Value Missing or 0			Value Out of Normal Bounds
		First Pass	Second Pass (First Pass Unsuccessful)	Third Pass (First 2 Passes Unsuccessful)	
Stack height	1–1,300 ft (0.3048–396 m)	Use default value by Source Classification Code (SCC) (pstk file)	Use global default: 3 m	N/A	Use the minimum or maximum in-bound value if below or above bounds, respectively
Stack inside diameter	0.001–300 ft (0.0003048–91.4 m)	See above	Use global default: 0.2 m	N/A	See above
Stack exit gas temperature [a]	>0–4,000 °F (>255.4–2477.6 K)	See above	Use global default: 295.4 K	N/A	See above
Stack exit gas velocity	0.001–1000 ft/s (0.0003048–304.8 m/s)	Calculate from existing exit gas flow rate and inside diameter: (4*flow) / (pi*diameter^2)	Use default value by SCC (pstk file)	Use global default: 4 m/s	See above
Fugitive height	N/A	3.048 m if length or width missing or 0. (Leave at 0 m if length and width are not missing and are above 0.)	N/A	N/A	N/A
Fugitive length	N/A	10 m	N/A	N/A	N/A
Fugitive width	N/A	10 m	N/A	N/A	N/A
Fugitive angle	N/A	0 deg	N/A	N/A	N/A

SCC = Source Classification Code
[a] For exit gas temperatures, AirToxScreen's value bounds were modified so that values must be above 0 °F.
Notes:
pstk file = file of default stack parameters by source classification code (SCC) from EPA's SMOKE emissions kernel: pstk_13nov2018_v1.txt, retrieved on 28 September 2022 from https://cmascenter.org/smoke/, (accessed December 5, 2025)

Table_Apx H-6 details the numbers of modeled sources and the numbers of sources that had replaced values of physical source specifications following the rules in Table_Apx H-5.

Table_Apx H-6. Details on Where Replacements Were Made for Physical Source Specifications

Release Year	Source Type	Number of Sources	Release Height	Stack Inside Diameter	Stack Exit Gas Velocity	Stack Exit Gas Temperature	Fugitive Length	Fugitive Width	Fugitive Angle
2017	Point	Vertical: 381 Horizontal: 13 Downward Facing Vent: 21 TOTAL: 415	No issues	No issues	Problem: 120 sources with values of 0. Solution: Replaced with value calculated from exit gas flow rate and inside stack diameter. Two replacements were above bounds and capped at 304.8 m/s.	No issues	N/A	N/A	N/A
	Fugitive	370	Problem: 27 sources with values of 0, while also having values of 0 for fugitive length or fugitive width. Solution: Replaced with 3.048 m.	N/A	N/A	N/A	Problem: 52 sources with values of 0. Solution: Replaced with 10 m.	Problem: 52 sources with values of 0. Solution: Replaced with 10 m.	No issues
2020	Point	Vertical: 377 Horizontal: 27 Downward Facing Vent: 14 TOTAL: 434	No issues	No issues	Problem: 139 sources with missing values. Solution: Replaced with value calculated from exit gas flow rate and inside stack diameter. Two replacements were above bounds and capped at 304.8 m/s.	No issues	N/A	N/A	N/A
	Fugitive	385	Problem: 33 sources with missing values, while also having missing values for fugitive length or fugitive width. Solution: Replaced with 3.048 m.	N/A	N/A	N/A	Problem: 59 sources with missing values. Solution: Replaced with 10 m.	Problem: 59 sources with missing values. Solution: Replaced with 10 m.	No issues

H.1.4 HEM Radial Distances NEI-Based Cancer Risk Estimates

H.1.4.1 Tier III: Cancer Risk Estimates by Radial Distances from NEI Releases

EPA modeled exposure concentrations using HEM v5.0 and derived the lifetime cancer risks using Equation 5-2 for all radial distances evaluated for both the 2017 and 2020 NEI datasets. EPA set up the HEM v5.0 outputs to include the 95th, 50th, and 10th percentile modeled concentrations at all distances evaluated (11 finite distances and 2 area distances). For all NEI 2017 and 2020 modeled exposure concentrations and calculated MOEs and cancer risks for all distances from 10 to 50,000 m; see the supplemental file: *Human Exposure Model (HEM) NEI 2017 and 2021 Exposure and Risk Analysis for 1,3-Butadiene* (U.S. EPA, 2025v).

Table_Apx H-7 summarizes the lifetime cancer risk estimates derived from the 95th- and 50th percentile-modeled air concentrations of 1,3-butadiene by OES and associated COUs for three distances (100, 100–1,000, and 1,000 m) from the release point.

Based on the 95th percentile modeled concentrations, maximum cancer risks across all COUs/OESs, all three distances, and both 2017 and 2020 NEI datasets ranged from 5.1×10^{-7} to 6.2×10^{-4}. In total, 46 of the 55 facilities evaluated had individual cancer risk estimates at or above 1 in a million (1×10^{-6}).

Based on the 50th percentile modeled concentrations, maximum cancer risks across all COUs/OESs, all three distances, and both 2017 and 2020 NEI datasets ranged from 1.9×10^{-7} to 1.4×10^{-4}. In total, 42 of the 55 facilities evaluated had individual cancer risk estimates at or above 1 in a million.

The highest cancer risk estimates were found in the Processing – plastics and rubber polymerization and Manufacture – manufacturing COUs/OESs, along with Repackaging OES, which is tied to both Manufacture and Processing COUs.

Summary tables for cancer risk estimates based on the 95th and 50th percentile modeled concentrations from HEM across all distances by OESs and associated COUs across all distances from 10 to 50,000 m are in included below as Table_Apx H-8 and Table_Apx H-9, respectively.

Table_Apx H-7. General Population Cancer Risk Summary Table at 100–1,000 m from Facility NEI Releases Based on HEM-Modeled Concentrations

Life Cycle Stage	Category	Subcategory	Exposure Scenario	Facility Count	Facility Count Above 1E−06 at 100 m	Exposure Concentration Statistic	100 m	100–1,000 m	1,000 m
Manufacture	Domestic manufacturing	Domestic manufacturing	Manufacturing	17	12	95th percentile	7.8E−05	9.8E−05	2.1E−05
					12	50th percentile	2.5E−05	1.4E−05	4.3E−06
Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and Rubber Polymerization	19	18	95th percentile	6.2E−04	1.7E−04	7.7E−06
					18	50th percentile	1.4E−04	1.8E−05	4.7E−06
Processing	Processing – incorporation into article	Other: monomer in: rubber and plastic product manufacturing	Plastics and Rubber Compounding and Converting	1	1	95th percentile	4.4E−06	3.9E−06	5.1E−07
					1	50th percentile	2.3E−06	8.4E−07	1.9E−07
Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – Incorporation into Formulation, Mixture, or Reaction Product	2	2	95th percentile	1.1E−04	2.0E−05	2.1E−06
					1	50th percentile	4.5E−05	3.9E−06	9.3E−07
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	Processing as a Reactant	13	10	95th percentile	2.8E−04	4.4E−05	1.6E−05
					8	50th percentile	4.3E−05	1.4E−05	5.0E−06
Manufacture	Import	Import	Repackaging	3	3	95th percentile	2.2E−04	3.6E−05	4.4E−06
Processing	Repackaging	Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing			2	50th percentile	9.8E−06	9.1E−06	1.7E−06

Life Cycle Stage	Category	Subcategory	Exposure Scenario	Facility Count	Facility Count Above 1E−06 at 100 m	Exposure Concentration Statistic	100 m	100–1,000 m	1,000 m
			Total	**55**	**46**	**95th percentile**			
					42	**50th percentile**			

Table_Apx H-8. 1,3-Butadiene Cancer Risk Based on HEM 95th Percentile-Modeled Concentrations from 10–50,000 m

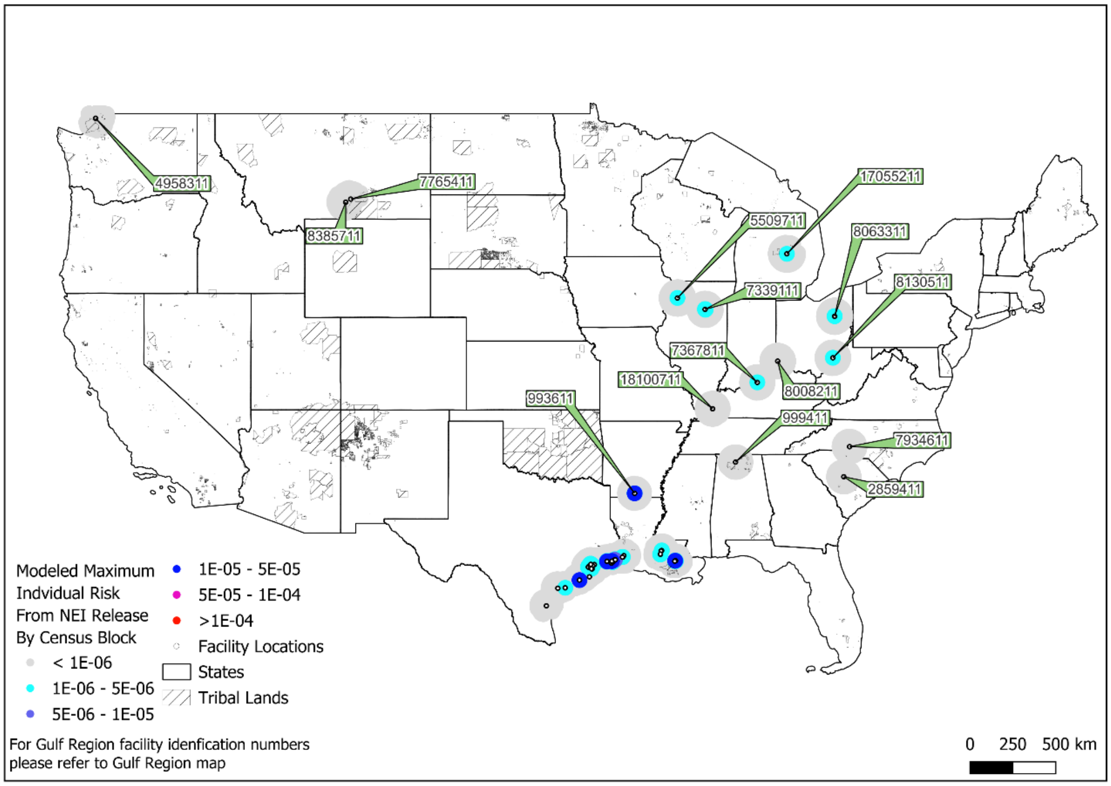
Life Cycle Stage	Category	Subcategory	OES	NEI Facilities		Estimated Cancer Risk Using Max. Concentration Across Facilities Within OES by Distance from All Sources (m) (Based on 95th Percentile-Modeled Concentrations)												
				Total	Risk Above 1E−06 at 100 m	10	30	30-60	60	100	100-1,000	1,000	2,500	5,000	10,000	15,000	25,000	50,000
Manufacture	Domestic manufacturing	Domestic manufacturing	Manufacturing	17	12	4.8E−05	4.9E−05	1.2E−04	6.6E−05	7.8E−05	9.8E−05	2.1E−05	2.4E−06	8.7E−07	3.2E−07	1.9E−07	9.9E−08	4.4E−08
Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber polymerization	20	18	3.3E−03	8.2E−04	1.1E−03	4.5E−04	6.2E−04	1.7E−04	7.7E−06	1.7E−06	5.8E−07	2.1E−07	1.1E−07	5.7E−08	2.1E−08
Processing	Processing – incorporation into article	Other: monomer in: rubber and plastic product manufacturing	Plastics and rubber compounding and converting	1	1	3.0E−06	3.4E−06	6.7E−06	3.9E−06	4.4E−06	3.9E−06	5.1E−07	1.1E−07	4.1E−08	1.6E−08	8.9E−09	4.3E−09	1.6E−09
Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	2	2	3.8E−03	9.8E−04	9.0E−04	2.9E−04	1.1E−04	2.0E−05	2.1E−06	4.7E−07	1.6E−07	5.6E−08	3.5E−08	1.9E−08	7.5E−09
Processing	Processing as a reactant	Intermediate in: adhesive manufacturing; all other basic organic chemical manufacturing; fuel binder for solid rocket fuels; organic fiber manufacturing;	Processing as a reactant	12	10	2.1E−04	2.6E−04	5.5E−04	2.8E−04	2.8E−04	4.4E−05	1.6E−05	2.6E−06	9.2E−07	3.5E−07	2.1E−07	1.1E−07	4.6E−08

Life Cycle Stage	Category	Subcategory	OES	NEI Facilities		Estimated Cancer Risk Using Max. Concentration Across Facilities Within OES by Distance from All Sources (m) (Based on 95th Percentile-Modeled Concentrations)												
				Total	Risk Above 1E−06 at 100 m	10	30	30-60	60	100	100-1,000	1,000	2,500	5,000	10,000	15,000	25,000	50,000
		petrochemical manufacturing; petroleum refineries; plastic material and resin manufacturing; propellant manufacturing; synthetic rubber manufacturing; paint and coating manufacturing																
Manufacture	Import	Import	Repackaging	3	3	1.5E−05	2.0E−05	4.3E−05	3.9E−05	2.2E−04	3.6E−05	4.4E−06	8.6E−07	2.7E−07	8.9E−08	4.7E−08	2.1E−08	7.4E−09
Processing	Repackaging	Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing																
			Total	**55**	**46**													

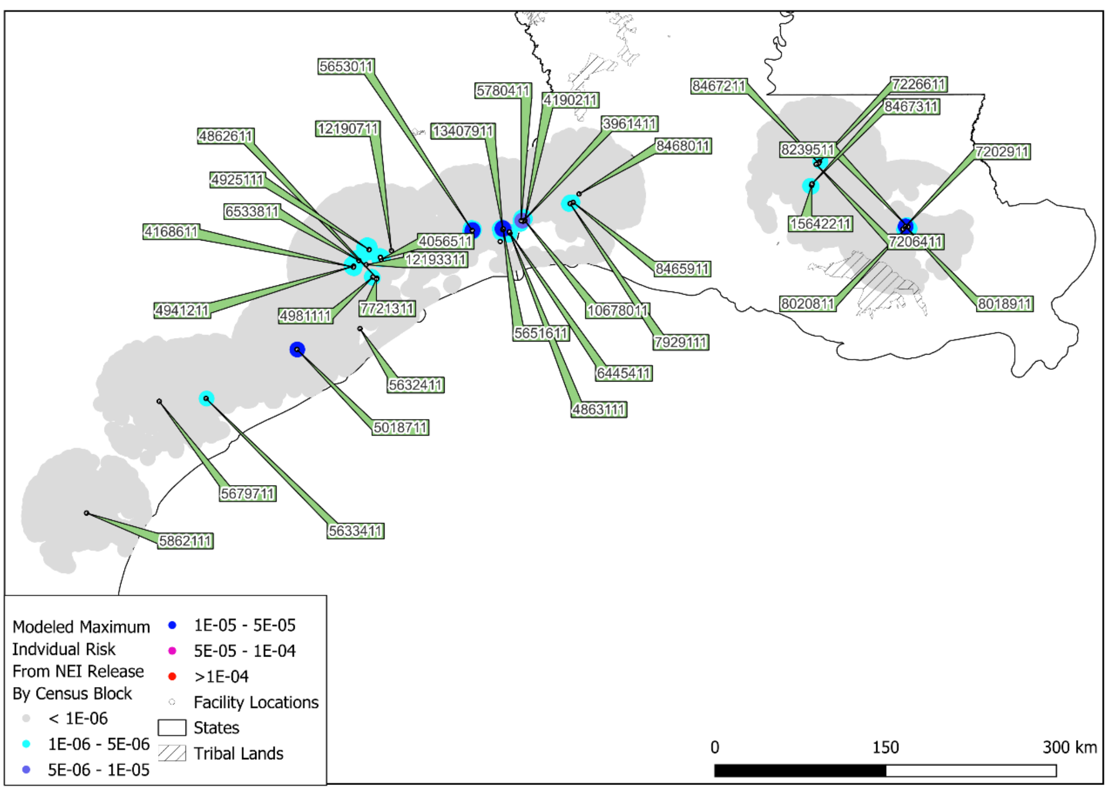
Table_Apx H-9. 1,3-Butadiene Cancer Risks Based on HEM 50th Percentile-Modeled Concentrations from 10–50,000 m

Life Cycle Stage	Category	Subcategory	OES	NEI Facilities		Estimated Cancer Risk Using Max. Concentration Across Facilities Within OES by Distance from All Sources (m) (Based on 50th Percentile Modeled Concentrations)												
				Total	Risk Above 1E−06 at 100 m	10	30	30–60	60	100	100–1,000	1,000	2,500	5,000	10,000	15,000	25,000	50,000
Manufacture	Domestic manufacturing	Domestic manufacturing	Manufacturing	17	12	2.7E−05	2.6E−05	5.2E−05	2.6E−05	2.5E−05	1.4E−05	4.3E−06	8.8E−07	3.1E−07	1.3E−07	7.9E−08	4.0E−08	1.7E−08
Processing	Processing as a reactant	Other: monomer used in polymerization process in: plastic material and resin manufacturing; manufacturing synthetic rubber and plastics	Plastics and rubber polymerization	20	18	1.1E−03	3.0E−04	3.3E−04	1.7E−04	1.4E−04	1.8E−05	4.7E−06	9.6E−07	3.2E−07	1.1E−07	6.6E−08	3.4E−08	1.3E−08
Processing	Processing – incorporation into article	Other: monomer in: rubber and plastic product manufacturing	Plastics and rubber compounding and converting	1	1	2.3E−06	2.3E−06	4.4E−06	2.3E−06	2.3E−06	8.4E−07	1.9E−07	4.6E−08	1.8E−08	7.2E−09	4.2E−09	2.1E−09	8.0E−10
Processing	Processing – incorporation into formulation, mixture, or reaction product	Processing aids, not otherwise listed in: petrochemical manufacturing	Processing – incorporation into formulation, mixture, or reaction product	2	1	1.0E−03	2.7E−04	3.6E−04	1.0E−04	4.5E−05	3.9E−06	9.3E−07	2.1E−07	6.9E−08	2.6E−08	1.4E−08	7.5E−09	3.5E−09
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	Processing as a reactant	12	8	1.5E−04	1.0E−04	1.4E−04	5.8E−05	4.3E−05	1.4E−05	5.0E−06	9.3E−07	3.6E−07	1.6E−07	9.8E−08	5.0E−08	2.0E−08

Life Cycle Stage	Category	Subcategory	OES	NEI Facilities		Estimated Cancer Risk Using Max. Concentration Across Facilities Within OES by Distance from All Sources (m) (Based on 50th Percentile Modeled Concentrations)												
				Total	**Risk Above 1E−06 at 100 m**	**10**	**30**	**30–60**	**60**	**100**	**100–1,000**	**1,000**	**2,500**	**5,000**	**10,000**	**15,000**	**25,000**	**50,000**
Manufacture	Import	Import	Repackaging	3	2	1.2E−05	1.2E−05	2.9E−05	1.1E−05	9.8E−06	9.1E−06	1.7E−06	3.5E−07	1.2E−07	3.9E−08	2.1E−08	9.6E−09	3.4E−09
Processing	Repackaging	Wholesale and retail trade fuel; synthetic rubber manufacturing; petrochemical manufacturing																
			Total	**55**	**42**													



Figure_Apx H-1. US Census Block Risk Estimates Based on 2017 NEI Releases



Figure_Apx H-2. Texas and Louisiana Census Block Risk Estimates Based on 2017 NEI Releases

Table_Apx H-10. TRI and NEI Facilities Cross Reference for HEM Modeling

TRI Facility ID	Facility Name	NEI EISD	Facility Name	OES	Street Address	City	State	Lat	Long	Notes
40216MRCNS4500C	AMERICAN SYNTHETIC RUBBER CO	7367811	American Synthetic Rubber Company	Plastics and rubber polymerization	4500 CAMPGROUND RD	LOUISVILLE	KY	38.20932	-85.8475	
77631PLYSRFM100	ARLANXEO	3961411	ORANGE PLANT	Plastics and rubber polymerization	4647 FM 1006	ORANGE	TX	30.04715	-93.7698	
77643BSFFNNEOFI	BASF TOTAL PETROCHEMICALS LLC	6445411	BASF TOTAL NAFTA REGION OLEFINS COMPLEX	Manufacturing	NE OF INTERSECTION OF HWY 73 & HWY 366	PORT ARTHUR	TX	29.95165	-93.8873	
77522CHVRN9500I	CHEVRON PHILLIPS CHEMICAL CO LP	12190711	CHEVRON CHEMICAL CO	Manufacturing	9500 IH-10 E	BAYTOWN	TX	29.826	-94.9219	
77465CHVRNSTATE	CHEVRON PHILLIPS CHEMICAL CO LP SWEENY COMPLEX	5018711	SWEENY REFINERY PETROCHEM	Manufacturing	21441 LOOP 419	SWEENY	TX	29.08154	-95.7417	
59044CNXRF803HI	CHS INC. LAUREL REFINERY	8385711	CHS INC REFINERY LAUREL	Processing as a reactant	803 HWY 212 S	LAUREL	MT	45.65922	-108.768	
77507DXCHM10701	DIXIE CHEMICAL CO INC	4862611	BAYPORT FACILITY	Processing as a reactant	10601 BAY AREA BLVD	PASADENA	TX	29.61202	-95.0505	
77541THDWCBUILD	DOW CHEMICAL CO FREEPORT FACILITY	4897811	OYSTER CREEK COGENERATION POWER UNIT 8	Processing as a reactant	2301 N BRAZOSPORT BLVD	FREEPORT	TX	28.9792	-95.3549	No reported NEI 2017 or 2020 Release
75607TXSSTOFFHI	EASTMAN CHEMICAL CO TEXAS OPERATIONS	7908711	EASTMAN COGENERATION FACILITY	Processing as a reactant	300 KODAK BLVD	LONGVIEW	TX	32.43806	-94.69	No reported NEI 2017 or 2020 Release
52732QNTMCUSHWY	EQUISTAR CHEMICALS CLINTON PLANT	5509711	EQUISTAR CHEMICALS, LP	Plastics and rubber polymerization	3400 ANAMOSA RD HWY 30 W	CLINTON	IA	41.807	-90.296	
78410CCPCC1501M	EQUISTAR CHEMICALS LP	5862111	CORPUS CHRISTI PLANT	Plastics and rubber polymerization	1501 MCKINZIE RD	CORPUS CHRISTI	TX	27.81	-97.5936	
70805XXNCH4999S	EXXONMOBIL BATON ROUGE CHEMICAL PLANT (PART)	7226611, 21462111	EXXON MOBIL CORPORATION - BATON ROUGE CHEMICAL PLANT and EXXONMOBIL PIPELINE COMPANY LLC - BRCP CHEMICAL METER SITE	Manufacturing	4999 SCENIC HWY	BATON ROUGE	LA	30.49577	-91.1731	

TRI Facility ID	Facility Name	NEI EISD	Facility Name	OES	Street Address	City	State	Lat	Long	Notes
70805XXNBT4050S	EXXONMOBIL BATON ROUGE REFINERY (PART)	8467211, 19253511, 19253811, 5160311	EXXON MOBIL CORPORATION - BATON ROUGE REFINERY; EXXONMOBIL PIPELINE COMPANY LLC - EAST BANK VALVE SITE; VWNA PROCESS SOLUTIONS/TEXAS LLC; EXXONMOBIL REFINING & SUPPLY CO - PROCESS RESEARCH LABORATORIES	Manufacturing	4045 SCENIC HWY	BATON ROUGE	LA	30.48492	-91.1739	
77522XXNCH3525D	EXXONMOBIL CHEMICAL CO BAYTOWN OLEFINS PLANT (PART)	4056511	BAYTOWN OLEFINS PLANT	Manufacturing	3525 DECKER DR	BAYTOWN	TX	29.75626	-95.011	
77522XXNBY2800D	EXXONMOBIL REFINING & SUPPLY BAYTOWN REFINERY (PART)	4924411	BAYTOWN REFINERY	Manufacturing	2800 DECKER DR	BAYTOWN	TX	29.73944	-95.0069	No Reported NEI 2017 or 2020 Release
70602FRSTNLA108	FIRESTONE POLYMERS LLC	8465911	FIRESTONE POLYMERS LLC - LAKE CHARLES FACILITY	Plastics and rubber polymerization	1801 E LA HWY 108	SULPHUR	LA	30.18614	-93.3312	
77978FRMSPPOBOX	FORMOSA PLASTICS CORP TEXAS	5633411	FORMOSA POINT COMFORT PLANT	Plastics and rubber polymerization	201 FORMOSA DR	POINT COMFORT	TX	28.6753	-96.5495	
77720THGDYINTER	GOODYEAR TIRE & RUBBER CO	5653011	BEAUMONT CHEMICAL PLANT	Plastics and rubber polymerization	11241 INTERSTATE HWY 10	BEAUMONT	TX	29.97456	-94.2166	
44301BFGDR240WE	HUNTSMAN ADVANCED MATERIALS AMERICAS LLC	8063311	Huntsman Advanced Materials Americas, LLC (1677010029); Emerald Performance Materials, LLC (1677010029)	Processing as a reactant	240 W EMERLING AVE	AKRON	OH	41.04567	-81.5418	
77651TXCCHHWY36	HUNTSMAN PETROCHEMICAL LLC PORT NECHES FACILITY	6362811	HUNTSMAN CORP OXIDES AND OLEFINS (O & O) FACILIT	Processing – incorporation into formulation, mixture, or reaction product	6001 HWY 366	PORT NECHES	TX	29.99015	-93.9467	No Reported NEI 2017 or 2020 Release

TRI Facility ID	Facility Name	NEI EISD	Facility Name	OES	Street Address	City	State	Lat	Long	Notes
35601MCCHMFINLE	INDORAMA VENTURES	999411	INDORAMA VENTURES XYLENES & PTA, LLC	Processing as a reactant	1401 FINLEY ISLAND RD	DECATUR	AL	34.6415	-87.0589	
45001MNSNT356TH	INEOS USA LLC	8364911, 8364811, 8008211	SOLUTIA PORT PLASTICS; HERCULES - PORT PLASTICS; INEOS ABS (USA) CORPORATION (1431010054)	Plastics and rubber polymerization	356 THREE RIVERS PKWY	ADDYSTON	OH	39.1347	-84.7122	
77511MCCHM2MISO	INEOS USA LLC - CHOCOLATE BAYOU PLANT	5632411	CHOCOLATE BAYOU PLANT	Manufacturing	2 MILES S OF INTERSECTION FM2004 & FM2917	ALVIN	TX	29.41377	-95.2637	
77630NVSTS355AF	INV NYLON CHEMICALS AMERICAS ORANGE SITE	10678011	ORANGE SITE	Plastics and rubber polymerization	3055A FM 1006	ORANGE	TX	30.05417	-93.7522	
77905NVSTS2695L	INV NYLON CHEMICALS AMERICAS VICTORIA SITE	5679711	VICTORIA SITE	Plastics and rubber polymerization	2695 OLD BLOOMINGTON RD NORTH	VICTORIA	TX	28.67306	-96.9536	
77507NSSKC10500	JX NIPPON CHEMICAL TEXAS INC	7721311	NCTIUS	Processing as a reactant	10500 BAY AREA BLVD	PASADENA	TX	29.60861	-95.0519	
77507KNKTX6161U	KANEKA NORTH AMERICA LLC	4981111, 4019411	KANEKA PASADENA SITE; APICAL DIVISION	Plastics and rubber polymerization	6161 UNDERWOOD RD	PASADENA	TX	29.62165	-95.0851	
45714SHLLC2982W	KRATON POLYMERS US LLC	8130511	KRATON POLYMERS U.S. LLC (0684010011)	Plastics and rubber polymerization	2419 STATE RT 618	BELPRE	OH	39.28107	-81.6379	
77521NCHML4803D	LCY ELASTOMERS LP	6535111	BAYTOWN FACILITY	Plastics and rubber compounding and converting	4803 DECKER DR	BAYTOWN	TX	29.77209	-95.0195	
29201LNDCH750GR	LINDAU CHEMICALS INC.	2859411	LINDAU CHEMICALS INC	Processing as a reactant	750 GRANBY LN	COLUMBIA	SC	33.97216	-81.0315	
77651SPSYN1615M	LION ELASTOMERS LLC	5651611, 4017211	PORT NECHES SYNTHETIC RUBBER PLANT; AMERIPOL SYNPOL CORP.	Plastics and Rubber Polymerization	1615 MAIN ST	PORT NECHES	TX	29.98766	-93.945	

TRI Facility ID	Facility Name	NEI EISD	Facility Name	OES	Street Address	City	State	Lat	Long	Notes
77630FRSTNFARMR	LION ELASTOMERS ORANGE LLC	5780411	ORANGE PLANT	Plastics and rubber polymerization	5713 FM 1006	ORANGE	TX	30.04209	-93.8325	
77530RCCHM2502S	LYONDELL CHEMICAL CO	4941411	CHANNELVIEW PLANT	Processing as a reactant	2502 SHELDON RD	CHANNELVIEW	TX	29.81665	-95.1076	No Reported NEI 2017 or 2020 Release
28213NCLCH14700	MALLARD CREEK POLYMERS	7934611	Mallard Creek Polymers, Inc.	Processing as a reactant	2800 MOREHEAD RD	CHARLOTTE	NC	35.35033	-80.7148	
77641TXCCHGATE2	MOTIVA CHEMICALS LLC	6430411	PORT ARTHUR CHEMICALS	Processing as a reactant	4241 SAVANNAH AVE	PORT ARTHUR	TX	29.89278	-93.9733	
77631DPNTSFARMR	PERFORMANCE MATERIALS NA INC	4190211	SABINE RIVER OPERATIONS	Plastics and rubber polymerization	FARM RD 1006	ORANGE	TX	30.0548	-93.7539	
59101CNCBL401SO	PHILLIPS 66 CO BILLINGS REFINERY	7765411	BILLINGS REFINERY	Processing as a reactant	401 S 23RD ST	BILLINGS	MT	45.77639	-108.484	
98248MBLLC3901U	PHILLIPS 66 FERNDALE REFINERY	4958311	PHILLIPS 66 FERNDALE REFINERY	Processing – Incorporation into formulation, mixture, or reaction product	3901 UNICK RD	FERNDALE	WA	48.83014	-122.692	
61350BRGWRCANAL	SABIC INNOVATIVE PLASTICS US LLC	7339111	SABIC Innovative Plastics US LLC	Plastics and rubber polymerization	2148 N 2753RD RD	OTTAWA	IL	41.33453	-88.7558	
70669VSTCHOLDSP	SASOL CHEMICALS (USA) LLC-LAKE CHARLES CHEMICAL COMPLEX	8468011	SASOL CHEMICALS (USA) LLC - LAKE CHARLES CHEMICAL COMPLEX	Manufacturing	2201 OLD SPANISH TRAIL	WESTLAKE	LA	30.2588	-93.2937	
77536SHLLLHIGHW	SHELL CHEMICAL LP	21608511, 4982011, 12193311	DEER PARK OIL REFINERY; DEER PARK; SHELL DEER PARK REFINERY	Manufacturing	5900 HWY 225 EAST	DEER PARK	TX	29.72222	-95.1269	
70079SHLLL1205R	SHELL NORCO CHEMICAL PLANT	8020811, 8239511	EQUILON ENTERPRISES LLC - NORCO REFINERY; SHELL CHEMICAL LP - NORCO CHEMICAL PLANT – EAST SITE	Manufacturing	15536 RIVER RD	NORCO	LA	30.00096	-90.4039	

TRI Facility ID	Facility Name	NEI EISD	Facility Name	OES	Street Address	City	State	Lat	Long	Notes
70079SHLLL265RI	SHELL NORCO CHEMICAL PLANT WEST SITE	8018911	Shell Chemical LP - Norco Chemical Plant West Site	Repackaging	16122 RIVER RD	NORCO	LA	30.0053	-90.423	
70057NNCRBHWY31	ST CHARLES OPERATIONS (TAFT/STAR) UNION CARBIDE CORP	21461711, 7202911, 21966611	VOPAK INDUSTRIAL INFRASTRUCTURE AMERICAS ST CHARLES LLC - VOPAK TERMINAL ST. CHA; UNION CARBIDE CORP - ST CHARLES OPERATIONS; DOW INFRACO LLC - ST CHARLES OPERATIONS	Manufacturing	355 LA HWY 3142 (GATE 1)	HAHNVILLE	LA	29.9829	-90.4437	
77547DYNGY12801	TARGA DOWNSTREAM LLC - GALENA PARK MARINE TERMINAL	6533811	GALENA PARK TERMINAL	Repackaging	12510 AMERICAN PETROLEUM RD	GALENA PARK	TX	29.74735	-95.2028	
70765THDWCHIGHW	THE DOW CHEMICAL CO - LOUISIANA OPERATIONS	8467311, 21966411	THE DOW CHEMICAL COMPANY - LOUISIANA OPERATIONS; DOW INFRACO LLC - LOUISIANA OPERATIONS	Processing as a reactant	21255 LA HWY 1 S	PLAQUEMINE	LA	30.3209	-91.239	
77262GDYRT2000G	THE GOODYEAR TIRE & RUBBER CO	4941211	HOUSTON CHEMICAL PLANT	Plastics and rubber polymerization	2000 GOODYEAR DR	HOUSTON	TX	29.70439	-95.2552	
77640FNLNDHIGHW	TOTALENERGIES PETROCHEMICALS & REFINING USA INC-PORT ARTHUR	4863111	PORT ARTHUR REFINERY	Manufacturing	7600 32ND ST	PORT ARTHUR	TX	29.95794	-93.8975	
77651TXSPT212SP	TPC GROUP	4945211, 13407911	PORT NECHES OPERATIONS; PORT NECHES OPERATIONS C4 PLANT	Manufacturing	2102 SPUR 136	PORT NECHES	TX	29.96415	-93.9301	
77017TXSPT8600P	TPC GROUP LLC	4168611	HOUSTON PLANT	Manufacturing	8600 PARK PL BLVD	HOUSTON	TX	29.69845	-95.2546	
3072WSTYRN1468P	TRINSEO	21264011	TRINSEO	Plastics and rubber polymerization	1468 PROSSER DR SE	DALTON	GA	34.63259	-84.9277	

TRI Facility ID	Facility Name	NEI EISD	Facility Name	OES	Street Address	City	State	Lat	Long	Notes
4866WSTYRN164BU	TRINSEO LLC-MI OPERATIONS	17055211	TRINSEO LLC-MI OPERATIONS	Plastics and rubber polymerization	1604 BUILDING	MIDLAND	MI	43.6173	-84.2	
7076WDXCPL21255	TSRC SPECIALTY MATERIALS LLC	15642211	TSRC SPECIALTY MATERIALS LLC - PLAQUEMINE MANUFACTURING PLANT	Plastics and rubber polymerization	21255 LA HWY 1	PLAQUEMINE	LA	30.31701	-91.2438	
77012HLLPT9701M	VALERO REFINING - TEXAS L.P. HOUSTON REFINERY	4182511	HOUSTON REFINERY	Processing as a reactant	9701 MANCHESTER	HOUSTON	TX	29.72227	-95.2544	No Reported NEI 2017 or 2020 Release
70663WSTLK900HA	WESTLAKE PETROCHEMICALS ETHYLENE	7928911, 8465211, 7929111	WESTLAKE PETROCHEMICALS LLC - POLY III; WESTLAKE STYRENE LLC - STYRENE MONOMER PRODUCTION FACILITY; WESTLAKE CHEMICAL OPCO LP - WESTLAKE PETROCHEMICAL COMPLEX	Manufacturing	900 E HIGHWAY 108	SULPHUR	LA	30.177	-93.357	
77530KSLVL17LAK	K-SOLV CHEMICALS LLC	NA	NA	Repackaging	1007 LAKESIDE DR	CHANNELVIEW	TX	29.76833	-95.1036	No NEI EIS
7066WLSNNT221LD	LOUISIANA INTEGRATED POLYETHYLENE JV LLC	19356011	LOUISIANA INTEGRATED POLYETHYLENE JV LLC	Processing as a Reactant	2201 OLD SPANISH TRL	WESTLAKE	LA	30.24502	-93.2756	No Reported NEI 2017 or 2020 Release
70767PLCDR1940L	PLACID REFINING CO LLC	7206411	PLACID REFINING CO LLC - PLACID REFINING CO	Manufacturing	1940 LOUISIANA HWY 1 N	PORT ALLEN	LA	30.4758	-91.2081	
7839WGLFCSSUTHF	GULF COAST GROWTH VENTURES LLC	NA	NA	Plastics and Rubber Polymerization	4589 FM 2986	GREGORY	TX	27.92979	-97.3219	No NEI EIS
37209NSHVL17176	SHELL NASHVILLE TERMINAL	7127511	SHELL OIL PRODUCTS US	Repackaging	1717 61ST AVE N	NASHVILLE	TN	36.16933	-86.8595	
71730LNLRF1000M	LION OIL CO	993611	LION OIL COMPANY	Processing as a reactant	1000 MCHENRY ST	EL DORADO	AR	33.20152	-92.6736	Modeled HEM TRI-based risk was below 1E−6

TRI Facility ID	Facility Name	NEI EISD	Facility Name	OES	Street Address	City	State	Lat	Long	Notes
77480PHLLPSH35A	PHILLIPS 66 CO SWEENY REFINERY COMPLEX	5018711	SWEENY REFINERY PETROCHEM	Repackaging	8189 OLD FM 524	OLD OCEAN	TX	29.07085	-95.7504	Modeled HEM TRI-based risk was below 1E−6
77530LYNDL8280S	EQUISTAR CHEMICALS	4925111	CHANNELVIEW COMPLEX	Processing as a reactant	8280 SHELDON RD	CHANNELVIEW	TX	29.8308	-95.1164	No Reported TRI 2016-2021 Release
42029WSTLK2468I	WESTLAKE VINYLS INC	18100711	Westlake Chemical OpCo LP	Processing - Incorporation into formulation, mixture, or reaction product	2468 IND US TRIAL PKWY	CALVERT CITY	KY	37.04814	-88.3332	Modeled HEM TRI-based risk was below 1E−6

H.2 Census Blocks TRI-Based and NEI-Based Risk Estimates Comparison

Although the TRI and NEI datasets both report industrial releases of 1,3-butadiene, there are various differences between the datasets as discussed in Section 4.1.1.1 that can lead to slight differences in the modeled air concentrations of 1,3-butadiene, depending on the dataset used. For example, the TRI dataset includes facility-wide annual releases while the NEI dataset includes emission unit level annual releases. Additionally, TRI reported releases are submitted directly by industry based on industry-specific information (process volume, performance testing, etc.), whereas NEI-reported releases may be submitted by industry, states, or another entity, and may be based on engineering estimates, or even AP-42 emission factors. Nonetheless, a benefit of the NEI dataset provides emission unit-specific release parameters and locations that are used as inputs into HEM for more refined modeling results compared to modeling with the TRI dataset.

EPA compared the release estimates and census block cancer risk estimates between the two datasets. The purpose of this comparison is to see the differences in releases reported and the impacts of these differences on the overall cancer risk estimates. This comparison revolves around the 51 facilities showing cancer risk estimates above relevant benchmarks which could be crosswalked between TRI and NEI reported releases (Table_Apx H-11). In total, 43 of the 51 facilities compared had lower cancer risk estimates based on the 2017 and 2020 NEI dataset when compared to cancer risk estimates from the TRI dataset. The NEI-based cancer risk estimates ranged from 1 to 5 orders of magnitude lower than the TRI-based cancer risk estimates. The remaining 8 of the 51 facilities compared had cancer risk estimates that were 1 to 2 orders of magnitude greater than the TRI-based risk estimates. When comparing reported releases between the TRI and NEI datasets, EPA found that TRI-reported releases tended to be higher than the corresponding NEI-reported releases. Generally, EPA found that large differences in reported release values were associated with large differences in the risk estimates. However, when facilities had similar reported release values in both TRI and NEI datasets, the NEI-based risk estimates were generally lower than the TRI-based risk estimates. In instances where NEI-based risk estimates were higher, this was mainly attributed to emission unit releases being located along the outer boundaries of the facility, and therefore closer to residential areas when compared to a centralized release location that was used to model with TRI releases. Some NEI-based risk estimates were higher due to the modeled receptor (*i.e.*, census block centroid was located within the facility boundaries compared to the TRI-based risk estimates where the modeled receptor was located outside the facility). This difference in modeled receptor locations is attributed to the differences in the latitude and longitude coordinates between TRI- and NEI-reported releases.

Table_Apx H-11. TRI-Based and NEI-Based Risk Estimates and Release Comparison

TRI ID	TRI Facility Name	NEI EIS ID	Facility Name	TRI to NEI 2017 Risk Ratio	TRI to NEI 2020 Risk Ratio	TRI to NEI 2017 Release Ratio	TRI to NEI 2020 Release Ratio	Notes
3072WSTYRN1468P	TRINSEO	21264011	TRINSEO	–	1.88	–	1.47	TRI and NEI 2020 release about the same, TRI-based risks higher
37209NSHVL17176	SHELL NASHVILLE TERMINAL	7127511	SHELL OIL PRODUCTS US	–	**7.60**	–	1.33	TRI and NEI 2020 release about the same, TRI-based risks higher
77536SHLLLHIGHW	SHELL CHEMICAL LP	12193311	DEER PARK OIL REFINERY; DEER PARK; SHELL DEER PARK REFINERY	**77,255.37**	–	**116,566.09**	–	TRI Release higher, incorrect EIS ID; corrected one included below: 4168511
77522CHVRN9500I	CHEVRON PHILLIPS CHEMICAL CO LP	12190711	CHEVRON CHEMICAL CO	**14,557.66**	–	**76,713.81**	–	TRI Release higher than NEI 2017: reported 0 tons
77640FNLNDHIGHW	TOTALENERGIES PETROCHEMICALS & REFINING USA INC-PORT ARTHUR	4863111	PORT ARTHUR REFINERY	**2,008.25**	**1,463.12**	**336.24**	**56.80**	TRI Release higher, TRI-based risks higher
28213NCLCH14700	MALLARD CREEK POLYMERS	7934611	Mallard Creek Polymers, Inc.	**327.32**	**121.99**	**60.46**	**22.53**	TRI Release higher, TRI-based risks higher
70079SHLLL1205R	SHELL NORCO CHEMICAL PLANT	8020811	EQUILON ENTERPRISES LLC - NORCO REFINERY; SHELL CHEMICAL LP - NORCO CHEMICAL PLANT – EAST SITE	**6.41**	**16.58**	**17.12**	**18.74**	TRI Release higher, TRI-based risks higher
98248MBLLC3901U	PHILLIPS 66 FERNDALE REFINERY	4958311	PHILLIPS 66 FERNDALE REFINERY	**173.93**	**11.02**	**17.10**	1.02	TRI Release higher, TRI-based risks higher

TRI ID	TRI Facility Name	NEI EIS ID	Facility Name	TRI to NEI 2017 Risk Ratio	TRI to NEI 2020 Risk Ratio	TRI to NEI 2017 Release Ratio	TRI to NEI 2020 Release Ratio	Notes
78410CCPCC1501M	EQUISTAR CHEMICALS LP	5862111	CORPUS CHRISTI PLANT	**4.44**	**4.14**	**9.77**	**8.88**	TRI Release higher, TRI-based risks higher
70767PLCDR1940L	PLACID REFINING CO LLC	7206411	PLACID REFINING CO LLC - PLACID REFINING CO	**51.43**	**288.45**	**9.77**	**28.23**	TRI Release higher, TRI-based risks higher
77651TXSPT212SP	TPC GROUP	13407911	PORT NECHES OPERATIONS; PORT NECHES OPERATIONS C4 PLANT	**5.49**	**6.11**	**7.48**	**15.69**	TRI Release higher, TRI-based risks higher
70057NNCRBHWY31	ST CHARLES OPERATIONS (TAFT/STAR) UNION CARBIDE CORP	7202911	VOPAK INDUSTRIAL INFRASTRUCTURE AMERICAS ST CHARLES LLC - VOPAK TERMINAL ST. CHA; UNION CARBIDE CORP - ST CHARLES OPERATIONS; DOW INFRACO LLC - ST CHARLES OPERATIONS	**8.93**	1.17	**5.58**	1.12	TRI Release higher than NEI 2017 but about same for NEI 2020
77465CHVRNSTATE	CHEVRON PHILLIPS CHEMICAL CO LP SWEENY COMPLEX	5018711	SWEENY REFINERY PETROCHEM	*0.15*	*0.13*	**5.17**	**3.76**	TRI Release higher, NEI-based risks higher: NEI receptor located within facility
77507NSSKC10500	JX NIPPON CHEMICAL TEXAS INC	7721311	NCTIUS	**177.57**	**153.38**	**4.49**	**3.87**	TRI Release higher, TRI-based risks higher
70669VSTCHOLDSP	SASOL CHEMICALS (USA) LLC-LAKE CHARLES CHEMICAL COMPLEX	8468011	SASOL CHEMICALS (USA) LLC - LAKE CHARLES CHEMICAL COMPLEX	**97.37**	**42.99**	**4.29**	*0.54*	TRI Release higher than NEI 2017 but lower than NEI 2020, TRI-based risks higher
70602FRSTNLA108	FIRESTONE POLYMERS LLC	8465911	FIRESTONE POLYMERS LLC - LAKE CHARLES FACILITY	**13.82**	**20.09**	**4.10**	**8.49**	TRI Release higher, TRI-based risks higher

TRI ID	TRI Facility Name	NEI EIS ID	Facility Name	TRI to NEI 2017 Risk Ratio	TRI to NEI 2020 Risk Ratio	TRI to NEI 2017 Release Ratio	TRI to NEI 2020 Release Ratio	Notes
77017TXSPT8600P	TPC GROUP LLC	4168611	HOUSTON PLANT	1.72	1.78	**2.59**	**2.56**	TRI Release higher, similar risk estimates
45714SHLLC2982W	KRATON POLYMERS US LLC	8130511	KRATON POLYMERS U.S. LLC (0684010011)	**2.90**	**4.02**	**2.53**	**3.67**	TRI Release higher, TRI-based risks higher
52732QNTMCUSHWY	EQUISTAR CHEMICALS CLINTON PLANT	5509711	EQUISTAR CHEMICALS, LP	1.83	*0.16*	**2.43**	1.35	TRI Release higher than NEI 2017 but about same for NEI 2020, NEI 2020 risk estimate higher: same census block
77507DXCHM10701	DIXIE CHEMICAL CO INC	4862611	BAYPORT FACILITY	**29.49**	**12.20**	**2.39**	1.00	TRI Release higher than NEI 2017 but about same for NEI 2020, TRI-based risks higher
70079SHLLL1205R	SHELL NORCO CHEMICAL PLANT	8239511	EQUILON ENTERPRISES LLC - NORCO REFINERY; SHELL CHEMICAL LP - NORCO CHEMICAL PLANT – EAST SITE	**6.41**	**16.58**	**2.25**	**6.44**	TRI Release higher, TRI-based risks higher
77641TXCCHGATE2	MOTIVA CHEMICALS LLC	6430411	PORT ARTHUR CHEMICALS	**5.02**	**4.83**	**2.10**	1.80	TRI Release higher, TRI-based risks higher
77262GDYRT2000G	THE GOODYEAR TIRE & RUBBER CO	4941211	HOUSTON CHEMICAL PLANT	**2.72**	*0.70*	**2.02**	0.72	TRI Release higher than NEI 2017 but lower than NEI 2020
77630FRSTNFARMR	LION ELASTOMERS ORANGE LLC	5780411	ORANGE PLANT	**38.46**	**22.43**	1.95	1.29	TRI and NEI Release about the same, TRI-based risks higher

TRI ID	TRI Facility Name	NEI EIS ID	Facility Name	TRI to NEI 2017 Risk Ratio	TRI to NEI 2020 Risk Ratio	TRI to NEI 2017 Release Ratio	TRI to NEI 2020 Release Ratio	Notes
59101CNCBL401SO	PHILLIPS 66 CO BILLINGS REFINERY	7765411	BILLINGS REFINERY	**33.57**	**13.97**	1.94	1.04	TRI and NEI Release about the same, TRI-based risks higher
70805XXNCH4999S	EXXONMOBIL BATON ROUGE CHEMICAL PLANT (PART)	7226611	EXXON MOBIL CORPORATION - BATON ROUGE CHEMICAL PLANT and EXXONMOBIL PIPELINE COMPANY LLC - BRCP CHEMICAL METER SITE	**2.96**	**4.26**	1.84	1.75	TRI and NEI Release about the same, TRI-based risks higher
77630NVSTS355AF	INV NYLON CHEMICALS AMERICAS ORANGE SITE	10678011	ORANGE SITE	**10.12**	**4.52**	1.83	1.25	TRI and NEI Release about the same, TRI-based risks higher
77978FRMSPPOBOX	FORMOSA PLASTICS CORP TEXAS	5633411	FORMOSA POINT COMFORT PLANT	**10.85**	**9.82**	1.78	**11.99**	TRI release about the same as NEI 2017, higher than NEI 2020, TRI-based risks higher
44301BFGDR240WE	HUNTSMAN ADVANCED MATERIALS AMERICAS LLC	8063311	Huntsman Advanced Materials Americas, LLC (1677010029); Emerald Performance Materials, LLC (1677010029)	**2.26**	1.31	1.75	1.20	TRI and NEI Release about the same
77643BSFFNNEOFI	BASF TOTAL PETROCHEMICALS LLC	6445411	BASF TOTAL NAFTA REGION OLEFINS COMPLEX	**4.19**	**4.12**	1.72	**2.60**	TRI and NEI Release about the same, TRI-based risks higher
59044CNXRF803HI	CHS INC. LAUREL REFINERY	8385711	CHS INC REFINERY LAUREL	**3.21**	**19.48**	1.59	**21.81**	TRI and NEI Release about the same, TRI-based risks higher

TRI ID	TRI Facility Name	NEI EIS ID	Facility Name	TRI to NEI 2017 Risk Ratio	TRI to NEI 2020 Risk Ratio	TRI to NEI 2017 Release Ratio	TRI to NEI 2020 Release Ratio	Notes
70663WSTLK900HA	WESTLAKE PETROCHEMICALS ETHYLENE	7929111	WESTLAKE PETROCHEMICALS LLC - POLY III; WESTLAKE STYRENE LLC - STYRENE MONOMER PRODUCTION FACILITY; WESTLAKE CHEMICAL OPCO LP - WESTLAKE PETROCHEMICAL COMPLEX	1.37	1.00	1.55	1.46	TRI and NEI Release about the same
29201LNDCH750GR	LINDAU CHEMICALS INC.	2859411	LINDAU CHEMICALS INC	**4.00**	**4.19**	1.52	1.47	TRI and NEI Release about the same, TRI-based risks higher
70805XXNBT4050S	EXXONMOBIL BATON ROUGE REFINERY (PART)	8467211	EXXON MOBIL CORPORATION - BATON ROUGE REFINERY; EXXONMOBIL PIPELINE COMPANY LLC - EAST BANK VALVE SITE; VWNA PROCESS SOLUTIONS/TEXAS LLC; EXXONMOBIL REFINING & SUPPLY CO - PROCESS RESEARCH LABORATORIES	**11.78**	**11.96**	1.51	1.78	TRI and NEI Release about the same, TRI-based risks higher
61350BRGWRCANAL	SABIC INNOVATIVE PLASTICS US LLC	7339111	SABIC Innovative Plastics US LLC	**2.98**	1.87	1.43	1.23	TRI and NEI Release about the same
77631PLYSRFM100	ARLANXEO	3961411	ORANGE PLANT	**2.39**	1.83	1.32	1.00	TRI and NEI Release about the same
77651SPSYN1615M	LION ELASTOMERS LLC	5651611	PORT NECHES SYNTHETIC RUBBER PLANT; AMERIPOL SYNPOL CORP.	1.73	1.40	1.30	0.90	TRI and NEI Release about the same

TRI ID	TRI Facility Name	NEI EIS ID	Facility Name	TRI to NEI 2017 Risk Ratio	TRI to NEI 2020 Risk Ratio	TRI to NEI 2017 Release Ratio	TRI to NEI 2020 Release Ratio	Notes
45001MNSNT356TH	INEOS USA LLC	8008211	SOLUTIA PORT PLASTICS; HERCULES - PORT PLASTICS; INEOS ABS (USA) CORPORATION (1431010054)	**12.30**	**5.24**	1.29	**2.05**	TRI and NEI Release about the same, TRI-based risks higher
77522XXNCH3525D	EXXONMOBIL CHEMICAL CO BAYTOWN OLEFINS PLANT (PART)	4056511	BAYTOWN OLEFINS PLANT	1.84	**2.04**	1.22	1.37	TRI and NEI Release about the same
40216MRCNS4500C	AMERICAN SYNTHETIC RUBBER CO	7367811	American Synthetic Rubber Company	*0.74*	**2.65**	1.22	**3.72**	TRI and NEI 2017 Release about the same, NEI 2017 risk higher
77905NVSTS2695L	INV NYLON CHEMICALS AMERICAS VICTORIA SITE	5679711	VICTORIA SITE	**2.41**	**2.12**	1.17	0.99	TRI and NEI Release about the same, TRI-based risks higher
77631DPNTSFARMR	PERFORMANCE MATERIALS NA INC	4190211	SABINE RIVER OPERATIONS	**4.29**	**8.96**	1.17	1.47	TRI and NEI Release about the same, TRI-based risks higher
70765THDWCHIGHW	THE DOW CHEMICAL CO - LOUISIANA OPERATIONS	8467311	THE DOW CHEMICAL COMPANY - LOUISIANA OPERATIONS; DOW INFRACO LLC - LOUISIANA OPERATIONS	1.88	**3.75**	1.13	1.52	TRI and NEI Release about the same
77720THGDYINTER	GOODYEAR TIRE & RUBBER CO	5653011	BEAUMONT CHEMICAL PLANT	*0.41*	*0.43*	1.11	1.52	TRI and NEI Release about the same, NEI-based risks higher: NEI receptor located within facility

TRI ID	TRI Facility Name	NEI EIS ID	Facility Name	TRI to NEI 2017 Risk Ratio	TRI to NEI 2020 Risk Ratio	TRI to NEI 2017 Release Ratio	TRI to NEI 2020 Release Ratio	Notes
77521NCHML4803D	LCY ELASTOMERS LP	6535111	BAYTOWN FACILITY	1.33	1.94	1.11	1.34	TRI and NEI Release about the same
77511MCCHM2MISO	INEOS USA LLC - CHOCOLATE BAYOU PLANT	5632411	CHOCOLATE BAYOU PLANT	**3.28**	**5.48**	1.10	1.92	TRI and NEI Release about the same, TRI-based risks higher
70079SHLLL265RI	SHELL NORCO CHEMICAL PLANT WEST SITE	8018911	Shell Chemical LP - Norco Chemical Plant West Site	*0.15*	*0.19*	1.09	1.39	TRI and NEI Release about the same, NEI-based risks higher
7076WDXCPL21255	TSRC SPECIALTY MATERIALS LLC	15642211	TSRC SPECIALTY MATERIALS LLC - PLAQUEMINE MANUFACTURING PLANT	1.56	1.62	1.08	1.77	TRI and NEI Release about the same
77507KNKTX6161U	KANEKA NORTH AMERICA LLC	4981111	KANEKA PASADENA SITE; APICAL DIVISION	1.45	**2.28**	1.00	1.47	TRI and NEI Release about the same, TRI-based risks higher
35601MCCHMFINLE	INDORAMA VENTURES	999411	INDORAMA VENTURES XYLENES & PTA, LLC	**4.60**	**10.79**	1.00	**3.11**	TRI and NEI 2017 Release about the same, NEI 2020 release higher, TRI-based risks higher
4866WSTYRN164BU	TRINSEO LLC-MI OPERATIONS	17055211	TRINSEO LLC-MI OPERATIONS	1.14	1.50	1.00	1.36	TRI and NEI Release about the same
77547DYNGY12801	TARGA DOWNSTREAM LLC - GALENA PARK MARINE TERMINAL	6533811	GALENA PARK TERMINAL	*0.42*	*0.57*	1.00	1.50	TRI and NEI Release about the same, NEI-based risks higher: NEI receptor located within facility

TRI ID	TRI Facility Name	NEI EIS ID	Facility Name	TRI to NEI 2017 Risk Ratio	TRI to NEI 2020 Risk Ratio	TRI to NEI 2017 Release Ratio	TRI to NEI 2020 Release Ratio	Notes
77536SHLLLHIGHW	SHELL CHEMICAL LP	4168511	DEER PARK OIL REFINERY; DEER PARK; SHELL DEER PARK REFINERY	**–**	**2.56**	0.81	1.56	TRI and NEI Release about the same, TRI-based risks higher
Yellow-highlighted, bolded = ratios greater than 2. Green-highlighted, italicized = ratios lower than 1.								

H.2.1 Deer Park Case Study

As a case study for the TRI/NEI comparison, EPA chose the Deer Park facility located in Houston, Texas. This is the same facility that was selected as a case study in the AECOM Evaluation of EPA TSCA Screening Level Approach presentation, which demonstrated refined modeling using NEI release data resulted in lower modeled air concentrations when compared to modeled air concentrations using TRI release data for this facility (see Docket ID: EPA-HQ-OPPT-2018-0451-0076 for more details); note that the peer-reviewed study is now available (Masoud et al., 2025). This facility reported similar release values to both the 2020 TRI reporting year and the 2020 NEI reporting year. The total release reported to each dataset was approximately 16.7 tons per year of 1,3-butadiene. Specifically, a total release of 15,213 kg was reported to the 2020 TRI (TRI IDs 77536DRPRK5900H and 77536SHLLLHIGHW) and a facility-wide release of 15,218 kg was extracted from the 2020 NEI (NEI EIS ID 4168511).

Applying the methodologies described previously for TRI and NEI for the HEM analyses, EPA modeled the ambient concentrations of 1,3-butadiene for this facility and pulled the census block risk estimates for all census blocks around this facility to compare across datasets. Across all matching census blocks, risk estimates based on the TRI 2020 releases were higher than risk estimates based on the NEI 2020 releases. Table_Apx H-12 presents the nearest 10 census blocks to the Deer Park facility along with an aerial image of the facility in Figure_Apx H-3. Table_Apx H-12 also provides a ratio of the TRI-based/NEI-based risk estimates, which provide a general value to show the difference between the two estimates. Generally, the NEI-based risk estimates for these 10 census blocks were about an order of magnitude lower than the corresponding TRI-based risk estimate. Because the reported releases modeled are nearly identical, EPA attributes the differences in cancer risk estimates to the NEI dataset, which provides emission unit-specific inputs (stack height, diameter, location, etc.).

Table_Apx H-12. Deer Park Case Study TRI-Based and NEI-Based Risk Estimate Comparison

Census Block ID	Lat	Long	Population	Cancer Risk Estimate			Distance from Census Block to Release Source (m)	
				TRI	NEI	TRI / NEI Ratio	TRI	NEI
3425002014	29.70981	-95.1264	56	1.47E−06	8.30E−07	**1.77**	1,381	1,340
3425002008	29.70825	-95.1293	100	9.66E−07	9.37E−07	**1.03**	1,571	1,541
3427001006	29.71035	-95.1225	41	1.32E−06	4.40E−07	**3.00**	1,388	1,333
3425002029	29.7088	-95.1274	51	1.26E−06	8.84E−07	**1.43**	1,493	1,456
3425002010	29.70818	-95.126	85	1.23E−06	6.93E−07	**1.78**	1,565	1,522
3427001007	29.70959	-95.1224	69	1.20E−06	4.09E−07	**2.94**	1,470	1,415
3427001008	29.70891	-95.1224	40	1.11E−06	3.91E−07	**2.85**	1,543	1,489
3425002018	29.7068	-95.1256	67	1.08E−06	6.01E−07	**1.80**	1,719	1,676
3425002009	29.70826	-95.1285	98	1.06E−06	8.71E−07	**1.21**	1,560	1,527
3427001009	29.70823	-95.1224	60	1.04E−06	3.78E−07	**2.74**	1,616	1,563
3425002017	29.70612	-95.1256	84	1.02E−06	5.70E−07	**1.79**	1,795	1,752

Figure_Apx H-3. Deer Park Facility TRI and NEI Release Sources and Census Blocks
Blue dot = TRI sources; Red dots and squares = NEI sources; Orange diamonds = census blocks

One additional finding from this case study feeds into the broader fit-for-purpose needs of the 1,3-butadiene risk evaluation. Looking at the risk estimates directly, all but one of the TRI-based risk estimates for these 10 census blocks are at or above 1 in a million, whereas all of the NEI-based risk estimates are below 1 in a million. Therefore, in this case study, the dataset is used for modeling can impact the overall characterizations of exposure and risk estimates. Although the census block risk estimates for this case study facility decreases using the NEI dataset, this facility represents only one of many facilities categorized under manufacturing COU. How TRI and NEI release impacts modeled concentrations and risk estimates will be facility-specific. Therefore, considering the needs of the 1,3-butadiene risk evaluation, EPA considered other facilities under the same COU to fully characterize exposure and risk estimates that inform risk determination and regulatory decision-making.

In conclusion, though the TRI and NEI datasets both capture reported releases, there are several differences between the two datasets that can impact modeled concentrations of 1,3-butadiene in the ambient air, exposures, and associated risks. Based on the findings from this comparison, the differences between these results can generally be attributed to differences in the reported release values in the TRI and NEI datasets. Additionally, the use of emission unit-specific input parameters like stack height and fugitive area, as well as location within the facility property, can also impact modeled concentrations, exposures, and associated risks. However, whether TRI, NEI, or both datasets should be included in future risk evaluations depends on the resulting findings of screening level analyses as well as the needs for the specific chemical risk evaluation to inform risk management and regulatory decision making.

H.3 Inhalation Cancer Risks Estimated by Previous EPA Assessments

1,3-Butadiene is a listed HAP under Section 112 of the CAA and subject to regulatory standards promulgated under Sections 112(d) and 112(f) of the CAA (see Appendix B.1). Under Section 112 of the CAA, following promulgation of these regulatory standards, EPA is required to conduct RTR, including residual risk reviews, of each regulatory standard by applicable source category. Although the objectives of these RTRs serve different statutory requirements and goals relative to EPA's risk evaluations conducted under TSCA, the approaches and results from the CAA RTRs and TSCA risk evaluations for inhalation exposure are comparable and briefly discussed here.

While 1,3-butadiene as a HAP is regulated under multiple standards promulgated under the CAA, a recent and relevant CAA RTR was completed for the NESHAP from the Synthetic Organic Chemical Manufacturing Industry. See *Residual Risk Assessment for the Synthetic Organic Chemical Manufacturing Industry (SOCMI) Source* (U.S. EPA, 2024c). This RTR evaluates risks from all HAP emissions from facilities within this source category and includes both total HAP and individual HAP estimated risks, including 1,3-butadiene.

EPA's Office of Air and Radiation (OAR) conducted modeling of 2017 NEI and reported releases from select facilities in EPA-HQ-OAR-2022-0730-0091. Monitoring data were reported for seven facilities on a weekly basis for 37 to 43 days, for a total of seven sampling periods between May and July 2022. OAR compared fenceline monitoring concentrations obtained and submitted to EPA in accordance with the information requests to model concentrations using AERMOD and the NEI emissions. From that comparison, results showed that fenceline monitoring concentrations obtained and submitted by industry facilities tended to be higher than EPA's modeled concentrations using AERMOD and based on the 2017 NEI release dataset.

The modeling approach used for this CAA RTR is similar to the approach used for this TSCA risk evaluation assessment including the use of HEM, the NEI dataset, and consideration of risks at the census block level for both population analysis and an aggregate risk from multiple facilities in proximity to the same census blocks. Some differences between the CAA RTR and the TSCA risk evaluation include the CAA RTR's use of the IRIS *Health Assessment of 1,3-Butadiene* (2002a) IUR of 3×10^{-5} per µg/m3. This TSCA risk evaluation uses an IUR of 5.8×10^{-6} per µg/m^3 derived from literature identified and reviewed by EPA's Systematic Review Process as described in Section 5.3. Additionally, the CAA RTR used only the 2017 NEI dataset (the latest released at the time of conducting the RTR) while the TSCA risk evaluation uses both the 2017 and 2020 NEI datasets. Furthermore, the CAA RTR population information is based on the 2010 Census data with adjustments for maximum individual risk (again latest data available at the time of conducting the RTR and integrated into the HEM v4.2) while this TSCA risk evaluation population information is based on the 2020 Census data integrated into the latest HEM version (v5.0).

Considering the similarities and differences between the CAA RTR and the TSCA risk evaluation and the fact that both evaluate risks, EPA compared the results between the two evaluations in this 1,3-butadiene risk evaluation. The facility comparison includes 23 facilities that reported releases to NEI and were evaluated under a COU as well as those that are regulated under the CAA RTR source category. The TSCA risk evaluation includes three additional facilities evaluated under a COU that were not regulated under the Synthetic Organic Chemical Manufacturing Industry (SOCMI) source category but are regulated under the Polymers and Resins Group I source category. Table_Apx H-13 summarizes the full list of facilities and risk estimates compared in this TSCA risk evaluation.

In general, this comparison found both the CAA RTR and the TSCA risk evaluation found cancer risk estimates at the census block level from exposure to industrial releases of 1,3-butadiene exceeding both 1 in a million and 1 in 100,000. For all facilities compared, the maximum individual risk attributable to 1,3-butadiene from each facility for the TSCA risk evaluation were found to be similar or lower than the highest census block risk estimates from the CAA RTR—though this is likely due to the use of a different IUR in the CAA RTR. Overall, results and risk estimates from the CAA RTR and the TSCA risk evaluation assessments are generally similar and together provide support and confidence to each assessment. However, the use of different IURs and different statutory requirements/goals of the CAA and TSCA may lead to some differences between overall findings, risk management, and regulatory decision making.

Table_Apx H-13. OCSPP and OAR RTR Risk Estimates Comparison

EIS ID	Facility Name	OAR RTR Risk Estimate [a]	OCSPP NEI 2017 Risk Estimate [b]	OCSPP NEI 2020 Risk Estimate [b]
8465911	FIRESTONE POLYMERS LLC*	–	1.6E−06	1.1E−06
5653011	GOODYEAR TIRE & RUBBER CO	20 in a million (2E−05)	3.4E−05	3.3E−05
5632411	INEOS USA LLC - CHOCOLATE BAYOU PLANT	4 in a million (4E−06)	8.3E−07	5.0E−07
5780411	LION ELASTOMERS ORANGE LLC*	–	1.1E−06	1.9E−06
8018911	SHELL NORCO CHEMICAL PLANT	10 and 30 in a million (1E−05 and 3E−05)	2.8E−05	2.2E−05
4863111	TOTALENERGIES PETROCHEMICALS & REFINING USA INC-PORT ARTHUR	4 in a million and 0.1 in a million (4E−06 and 1E−07)	4.9E−08	6.7E−08
8468011	SASOL CHEMICALS (USA) LLC-LAKE CHARLES CHEMICAL COMPLEX	1 in a million (1E−06)	3.2E−07	7.2E−07
13407911	TPC GROUP	30 in a million (3E−05)	5.7E−06	5.1E−06
3961411	ARLANXEO*	–	5.4E−06	7.1E−06
4168611	TPC GROUP HOUSTON PLANT	10 in a million (1E−05)	2.2E−06	2.1E−06
5651611	Port Neches Synthetic Rubber Plant	30 in a million (3E−05)	6.1E−06	7.6E−06
4925111	Equistar Chemicals Channelview Complex	20 in a million (2E−05)	3.8E−06	4.0E−06
7367811	American Synthetic Rubber Company	7 in a million (7E−05)	2.7E−06	7.6E−07
5862111	Equistar Chemical Corpus Christi Plant	6 in a million (6E−05)	1.2E−06	1.3E−06
17055211	TRINSEO LLC-MI OPERATIONS	5 in a million (5E−05)	1.8E−06	1.4E−06
4056511	EXXON MOBIL BAYTOWN OLEFINS PLANT	10 in a million (1E−05)	2.8E−06	2.5E−06
5019011	CHEVRON SWEENY OLD OCEAN FACILITIES	5 in a million (5E−06)	–	–
4168511	DEER PARK CHEMICALS	7 in a million (7E−06)	–	9.4E−07
7929111	Westlake Chemical OpCo LP	7 in a million (7E−06)	1.7E−06	2.4E−06
8130511	Kraton Polymers U.S. LLC	2 in a million (2E−06)	2.3E−06	1.7E−06
6445411	BASF TOTAL NAFTA REGION OLEFINS COMPLEX	4 in a million (4E−06)	1.9E−06	1.9E−06
6430411	PORT ARTHUR CHEMICALS	1 in a million (1E−06)	3.4E−07	3.5E−07
5632411	CHOCOLATE BAYOU PLANT	4 in a million (4E−06)	8.3E−07	5.0E−07
7226611	Exxon Mobil Corporation - Baton Rouge Chemical Plant	3 in a million (3E−06)	1.2E−06	8.3E−07
4941211	Goodyear Tire HOUSTON CHEMICAL PLANT	5 in a million (5E−06)	7.9E−07	3.0E−06
999411	Indorama Ventures Xylenes & PTA, LLC	1 in a million (1E−06)	4.3E−07	1.8E−07

* Not HON/Not Modeled (P&RI)
[a] OAR risk estimate based on IUR of 3E−05 per µg/m^3 from the IRIS Health Assessment of 1,3-Butadiene (U.S. EPA, 2002a).
[b] OCSPP risk estimate based on IUR of 5.8E−05 per µg/m^3 from the Human Health Assessment for 1,3-Butadiene (U.S. EPA, 2025y).

H.4 Potentially Exposed or Susceptible Subpopulations

Table_Apx H-14. Average Risks by Demographic Groups Within 5km of NEI Facilities

Proximity and Average Risk Results for All Demographic Groups Analyzed – 5 km Study Area Radius[a]										
	Total Population	**Age (years) 0–17**	**Age (years) 18–64**	**Age (years) ≥65**	**Below the Poverty Level[b]**	**Below Twice the Poverty Level[b]**	**Total Number ≥ 25 Years Old**	**Over 25 Without a High School Diploma [c]**	**People Living in Limited English Speaking Households [d]**	**People with 1 or More Disabilities [e]**
Nationwide demographic breakdown										
Total population [f]	334,369,975	73,779,881	205,129,512	55,460,582	41,977,891	95,614,101	229,010,904	25,093,509	17,072,312	40,368,464
Percentage of total		22.10%	61.30%	16.60%	12.60%	28.60%	68.50%	11.00%	5.10%	12.10%
State demographic breakdown										
Total population [f]	131,810,809	30,152,837	80,745,574	20,912,398	17,385,101	39,677,165	88,995,729	9,793,759	4,469,152	15,000,674
Percentage of total		22.90%	61.30%	15.90%	13.20%	30.10%	67.50%	11.00%	3.40%	11.40%
County demographic breakdown										
Total population [f]	13,187,136	3,151,724	8,225,871	1,809,541	1,851,733	4,123,219	8,761,982	1,102,926	795,903	1,549,631
Percentage of total		23.90%	62.40%	13.70%	14.00%	31.30%	66.40%	12.60%	6.00%	11.80%
Proximity results based on NEI 2020 modeled risk estimates										
Total population within 5 km of any facility	1,056,352	246,213	664,371	145,768	195,144	411,669	679,546	114,659	68,335	118,703
Percentage of total		23.30%	62.90%	13.80%	18.50%	39.00%	64.30%	16.90%	6.50%	11.20%
Average risk (in one million) [g]	**0.3**	**0.4**	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**	**0.4**	**0.6**	**0.3**

[a] The demographic percentages are based on the 2020 Decennial Census' block populations, which are linked to the Census' 2018–2022 American Community Survey (ACS) 5-year demographic averages at the block group level. To derive demographic percentages, it is assumed a block's demographics are the same as the block group in which it is contained. Demographics are tallied for all blocks falling within the indicated radius.

[b] The demographic percentages for people living below the poverty line or below twice the poverty line are based on Census ACS surveys at the block group level that do not include people in group living situations such as dorms, prisons, nursing homes, and military barracks. To derive the nationwide demographic percentages shown, these block group level tallies are summed for all block groups in the nation and then divided by the total U.S. population based on the 2018–2022 ACS. The study area's population counts are based on the methodology noted in footnote "a" to derive block-level demographic population counts, which are then divided by the respective total block-level population to derive the study area demographic percentages shown.

[c] The demographic percentage for people ≥ 25 years old without a high school diploma is based on Census ACS data for the total population 25 years old and older at the block group level, which is used as the denominator when calculating this demographic percentage.

[d] The Limited English Speaking population is estimated at the block group level by taking the product of the block group population and the fraction of Limited English Speaking households in the block group, assuming that the number of individuals per household is the same for Limited English Speaking households as for the general population, and summed over all block groups.

[e] The demographic percentages for people with one or more disabilities are based on Census ACS surveys at the tract level of civilian non-institutionalized people (*i.e.*, all U.S. civilians not residing in institutional group quarters facilities such as correctional institutions, juvenile facilities, skilled nursing facilities, and other long-term care living arrangements). To derive the nationwide demographic percentages shown, these tract-level tallies are summed for all tracts in the nation and then divided by the total U.S. population based on the 2018–2022 ACS. The

Proximity and Average Risk Results for All Demographic Groups Analyzed – 5 km Study Area Radius[a]										
	Total Population	Age (years) 0–17	Age (years) 18–64	Age (years) ≥65	Below the Poverty Level[b]	Below Twice the Poverty Level[b]	Total Number ≥ 25 Years Old	Over 25 Without a High School Diploma [c]	People Living in Limited English Speaking Households [d]	People with 1 or More Disabilities [e]

study areas' population counts are based on applying the census tract level percentage of people with one or more disabilities to each block group and block within the respective tract. The methodology noted in footnote "a" is then used to derive block-level demographic population counts, which are then divided by the respective total block-level population to derive the study area demographic percentages shown.

[f] The total nationwide population includes all 50 states, the District of Columbia, and Puerto Rico. The state and county populations include any states and counties, respectively, with census blocks within the radius of the modeled area.

[g] The population-weighted average risk takes into account risk levels at all populated block receptors in the entire modeled domain. Risks from the modeled emissions are at the census block level, based on the predicted outdoor concentration over a 70-year lifetime, and not adjusted for exposure factors. See the HEM5 Users Guide (accessed December 8, 2025) for more information.

Table_Apx H-15. Demographic Assessment for Population at Risk Within 5km of NEI Facilities

Demographic Assessment of Risk Results Based on NEI 2020 Modeled Risk Estimates – 5 km Study Area Radius[a]									
Population Basis	**Total Population**	**Age (years) 0–17**	**Age (years) 18–64**	**Age (years) ≥65**	**Below the Poverty Level [b]**	**Below Twice the Poverty Level [b]**	**Over 25 Without a High School Diploma [c]**	**People Living in Limited English Speaking Households [d]**	**People with 1 or More Disabilities [e]**
Nationwide [f]	334,369,975	22.10%	61.30%	16.60%	12.60%	28.60%	11.00%	5.10%	12.10%
State [f]	131,810,809	22.90%	61.30%	15.90%	13.20%	30.10%	11.00%	3.40%	11.40%
County [f]	13,187,136	23.90%	62.40%	13.70%	14.00%	31.30%	12.60%	6.00%	11.80%
Population with risk greater than or equal to 1 in 1 million [g h]	**60,786**	**28.10%**	**59.50%**	**12.30%**	**15.90%**	**37.70%**	**25.60%**	**12.20%**	**11.00%**

[a] The demographic percentages are based on the 2020 Decennial Census' block populations, which are linked to the Census' 2018–2022 American Community Survey (ACS) 5-year demographic averages at the block group level. To derive demographic percentages, it is assumed a block's demographics are the same as the block group in which it is contained. Demographics are tallied for all blocks falling within the indicated radius.
[b] The demographic percentages for people living below the poverty line or below twice the poverty line are based on Census ACS surveys at the block group level that do not include people in group living situations such as dorms, prisons, nursing homes, and military barracks. To derive the nationwide demographic percentages shown, these block group level tallies are summed for all block groups in the nation and then divided by the total U.S. population based on the 2018–2022 ACS. The study area's population counts are based on the methodology noted in footnote "a" to derive block-level demographic population counts, which are then divided by the respective total block-level population to derive the study area demographic percentages shown.
[c] The demographic percentage for people ≥25 years old without a high school diploma is based on Census ACS data for the total population 25 years old and older at the block group level, which is used as the denominator when calculating this demographic percentage.
[d] The Limited English Speaking population is estimated at the block group level by taking the product of the block group population and the fraction of Limited English Speaking households in the block group, assuming that the number of individuals per household is the same for Limited English Speaking households as for the general population, and summed over all block groups.
[e] The demographic percentages for people with one or more disabilities are based on Census ACS surveys at the tract level of civilian non-institutionalized people (*i.e.*, all U.S. civilians not residing in institutional group quarters facilities such as correctional institutions, juvenile facilities, skilled nursing facilities, and other long-term care living arrangements). To derive the nationwide demographic percentages shown, these tract level tallies are summed for all tracts in the nation and then divided by the total U.S. population based on the 2018-2022 ACS. The study areas' population counts are based on applying the Census tract level percentage of people with one or more disabilities to each block group and block within the respective tract. The methodology noted in footnote "a" is then used to derive block-level demographic population counts, which are then divided by the respective total block-level population to derive the study area demographic percentages shown.
[f] The total nationwide population includes all 50 states, the District of Columbia, and Puerto Rico. The state and county populations include any states and counties, respectively, with census blocks within the radius of the modeled area.
[g] The population-weighted average risk takes into account risk levels at all populated block receptors in the entire modeled domain. Risks from the modeled emissions are at the census block level, based on the predicted outdoor concentration over a 70-year lifetime, and not adjusted for exposure factors. See the HEM5 Users Guide (accessed December 8, 2025) for more information.
[h] The maximum modeled risk is 30 in 1 million based on NEI2020_June26 emissions. This maximum occurs at the single populated receptor with the highest modeled risk.

Appendix I CONSUMER EXPOSURE

I.1 Consumer Exposure Model

I.1.1 Modeling Methods

To determine if concentrations in toys present risk, EPA conducted a sensitivity analysis using the Consumer Exposure Model (CEM) to calculate steady state air concentration from 0.1 percent (0.001 weight fraction) and 1 m^2 surface area to 30 percent (0.30 weight fraction) and 4 m^2 surface area of toys. This represents the average concentration of 1,3-butadiene in the bedroom over 1 year, accounting for chemical emission and removal from the room. Surface area of toys was chosen as a variable because it is a factor in determining how much 1,3-butadiene is released from the toy. The surface area may represent one toy or a collection of toys where the user is exposed to the combined surface area of all the toys.

Within CEM, an appropriate model measuring the emission from an article (toy) in an environment and inhalation was chosen to represent routine contact with plastic toys.[10] This model calculates the partitioning of 1,3-butadiene emissions from a toy between indoor air, airborne articles, settled dust, and indoor sinks over time. It includes the removal of 1,3-butadiene in the environment such as air exchange, routine cleaning, and ventilation. The model then takes these combined calculated gas-phase and respirable particle concentrations of 1,3-butadiene in the air to calculate the chronic dose for various age groups. EPA chose to evaluate an infant (<1 year) as they represent the highest risk and most sensitive population among all age groups that could have routine exposure to toys.

When selecting article properties and use environment, EPA chose inputs that represent reasonable use of a toy by an infant. Within CEM, the most conservative default activity pattern assumes an infant is in a bedroom (36 m^3 default volume in CEM) for 10 hours a day. Table_Apx I-1 shows the inputs and rationale for the inputs.

Table_Apx I-1. Article Properties and Use Environment for a Toy

Inputs	Value	Source	Rationale
Density of Product/Article	1.1 g/cm^3	(Lu and Chen, 2023)	Assuming that ABS has a density of 1.04 g/cm the density of a toy may contain other material.
Thickness of Article Surface Layer	0.01 cm	(U.S. EPA, 2024a)	Assume that only a thin layer of surface of 0.01 cm will release 1,3-butadiene based on minimal migration rates to air. Any 1,3-butadiene deeper than the 0.01 cm surface within the toy will be trapped unless the material is broken down.
Use Environment	Residence-Bedroom (10 hours/day)	Professional judgment	Represents environment where infant would spend the most time in a day exposed to toys.

[10] See scenarios "E6: Emission from Article Placed in Environment" and A_INH1: Inhalation from Article Placed in Environment" in (U.S. EPA, 2023) for more details on the models.