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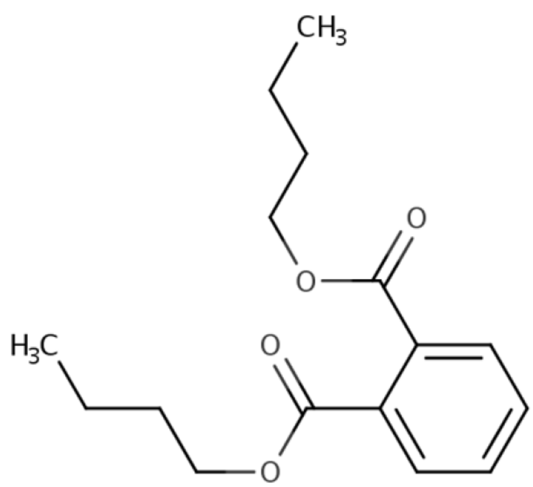
Draft Environmental Release and Occupational Exposure Assessment for Dibutyl Phthalate (DBP)

Technical Support Document for the Draft Risk Evaluation

CASRN 84-74-2



May 2025

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

KEY ABBREVIATIONS AND ACRONYMS

AC	Acute exposure concentration
ACGIH	American Conference of Governmental Industrial Hygienists
AD	Acute retained dose
ADD	Average daily dose
$ADC_{intermediate}$	Intermediate Average Daily Concentration
AIHA	American Industrial Hygiene Association
APDR	Acute potential dermal dose rate
APF	Assigned Protection Factor
AT_{acute}	Acute Averaging Time
AT_{C}	Averaging Time for Cancer Risk
AT_{I}	Averaging Time for Intermediate Exposure
AWD	Annual Working Days
BLS	Bureau of Labor Statistics (U.S.)
BR	Breathing rate
BW	Body weight
CDR	Chemical Data Reporting (rule)
CEB	Chemical Engineering Branch
CEHD	Chemical Exposure Health Database
CFR	Code of Federal Regulations
CEM	Consumer Exposure Model
CPS	Current Population Survey
CPSC	Consumer Product Safety Commission (U.S.)
CT	Central tendency
DD	Dermal Daily Dose
DBP	Dicyclohexyl phthalate
DMR	Discharge Monitoring Report
ECETOC TRA	European Centre for Ecotoxicology and Toxicology of Chemicals Targeted Risk Assessment
ED	Exposure duration
EF	Exposure frequency
EF_{int}	Intermediate Exposure Frequency
ELG	Effluent Limitation Guidelines
EPA	Environmental Protection Agency (U.S.) (or “the Agency”)
ESD	Emission scenario document
ETIMEOFF	Months When Not Working (CPS data)
G	Vapor Generation Rate
GS	Generic scenario
HAP	Hazardous Air Pollutant
HE	High-end
HVLP	High volume low pressure
IADC	Intermediate average daily concentration
IAD	Intermediate average daily dose
ID	Days for intermediate duration
IRER	Initial Review Engineering Report
LADC	Lifetime average daily concentrations
LADD	Lifetime average daily dose
LOD	Limit of detection
LT	Lifetime years for cancer risk

MW	Molecular weight of DBP
NAICS	North American Industry Classification System
NEI	National Emissions Inventory
NESHAP	National Emissions Standards of Hazardous Air Pollutants
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NIOSH	National Institute of Occupational Safety and Health
OARS	Occupational Alliance for Risk Science
OD	Operating days
OECD	Organisation for Economic Co-Operation and Development
OEL	Occupational Exposure Limit
OES	Occupational exposure scenario
OIS	Occupational Safety and Health Information System
ONU	Occupational non-users
OPPT	Office of Pollution Prevention and Toxics (EPA)
OSHA	Occupational Safety and Health Administration
OVS	OSHA Versatile Sampler
PAPR	Power air-purifying respirator
PBZ	Personal breathing zone
PEL	Permissible Exposure Limit
PF	Protection factor
POTW	Publicly owned treatment works
PPE	Personal protective equipment
PV	Production volume
RD	Release days
REL	Recommended Exposure Limits
$\rho_{product}$	Product density
ρ_{DBP}	DBP density
RQ	Reportable Quantity
SDS	Safety data sheet
SIC	Standard Industrial Classification
SIPP	Survey of Income and Program Participation
SpERC	Specific Emission Release Category
SAR	Supplied-air respirator
SCBA	Self-contained breathing apparatus
SRRP	Source Reduction Research Partnership
SUSB	Statistics of U.S. Businesses
T_{AGE}	Worker Age in SIPP
TDS	Technical data sheets
TJBIND1	Employed Individual Works (SIPP Data)
TLV	Threshold Limit Value
TMAKMNYR	First Year Worked (SIPP Data)
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
TSD	Technical support document
TWA	Time-weighted average
U.S.	United States
Vm_{DBP}	Molar volume of DBP
VP	DBP vapor pressure
WEEL	Workplace Environmental Exposure Level

WWT	Wastewater treatment
WY	Working years per lifetime

SUMMARY

This technical support document (TSD) accompanies the Toxic Substances Control Act (TSCA) *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025b). DBP is a Toxics Release Inventory (TRI)-reportable substance and is included on the TSCA Inventory, making it reportable under the Chemical Data Reporting (CDR) rule. This draft assessment describes the use of reasonably available information to estimate environmental releases of DBP and to evaluate occupational exposures. See the Draft Risk Evaluation for DBP for a complete list of all the TSDs for DBP.

Focus of the Environmental Release and Occupational Exposure Assessment for DBP

During scoping, EPA considered the TSCA conditions of use (COUs) for DBP. The 2020 CDR indicated 1 to 10 million pounds (lb) of DBP (CASRN 84-74-2) were manufactured or imported into the United States in 2019 (U.S. EPA, 2020a). The largest number of reported uses of DBP was as a plasticizer in plastics. Secondary uses for DBP are as a plasticizer/additive in adhesives, sealants, paints, coatings, rubbers, and other applications.

Exposures to workers, consumers, general populations, and ecological species may occur from releases of DBP to air, land, and water from industrial, commercial, and consumer uses of DBP and DBP-containing articles. Workers and occupational non-users (ONUs) may be exposed to DBP while handling solid and liquid formulations that contain DBP or during dust- and mist-generating activities that may be present during most COUs. ONUs are those who may work in the vicinity of chemical-related activities but do not handle the chemicals themselves, such as managers or inspectors. This draft TSD provides the details of the assessment of the environmental releases and occupational exposures from each COU of DBP.

Approach for Environmental Releases and Occupational Exposures Assessment for DBP

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

EPA evaluated environmental releases of DBP to air, water, and land from the OESs associated with the COUs assessed in the draft risk evaluation. The Agency reviewed release data from TRI (data from 2017–2022), Discharge Monitoring Reports (DMR; data from 2017–2022), and the 2017 and 2020 National Emissions Inventory (NEI) to identify relevant releases of DBP to the environment. These sources provide site-specific release information based on measurements, mass balances, or emission factors. In addition, EPA also considered other relevant release data to fill data gaps from other peer-reviewed or literature sources identified through systematic review. For OESs without any release data, the Agency used modeling approaches to assess release estimates.

EPA evaluated acute, intermediate, and chronic exposures of DBP to workers and ONUs for each OES. The Agency used (1) inhalation monitoring data from literature sources when available; and (2) exposure models where monitoring data were not available, or where these data were deemed insufficient for capturing exposures within the OES. EPA also used *in vitro* guinea pig absorption data along with modeling approaches to estimate dermal exposures to workers and ONUs.

Preliminary Results for Environmental Releases and Occupational Exposures to DBP

EPA evaluated environmental releases of DBP to air, water, and/or land for all OESs assessed in the

draft risk evaluation. Detailed release results for each OES to each type of assessed media can be found in Section 3 of this TSD. For overall releases, NEI generally provided the most release reports to air; however, the highest release estimates were provided by TRI for releases to land and water. Where data was not found in the available release databases, standard models were used to generate release estimates.

EPA also evaluated inhalation and dermal exposures to worker populations, including ONUs and females of reproductive age, for each OES. Detailed exposure results for each OES and exposure route can be found in Section 3 of this document.

Uncertainties of this Draft Assessment

Uncertainties exist with the monitoring data and modeling approaches used to assess DBP environmental releases and occupational exposures. One factor of uncertainty in the environmental releases includes the accuracy of the reported releases as well as the limitations in representativeness to all U.S. sites because TRI, DMR, and NEI may not capture all relevant sites due to reporting thresholds and different reporting protocols. More information on the reporting requirements for each of these databases is provided in Section 2.3.3. For modeled releases, the lack of DBP facility production volume data adds uncertainty; in such cases, EPA used throughput estimates based on CDR reporting thresholds, which may result in production volume estimates that are not representative of the actual production volume of DBP in the United States. The Agency also used generic EPA models and default input parameter values when site-specific data were not available. In addition, site-specific differences in use practices and engineering controls for DBP exist but are largely unknown. This represents another source of variability that EPA could not quantify in this draft assessment.

For inhalation exposures, the primary limitation of using monitoring data is the uncertainty of the representativeness of these exposure data toward the true distribution of inhalation concentrations at a specific facility. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin following dermal contact until the skin is washed. Therefore, in absence of DBP exposure duration data, for occupational dermal exposure assessment, EPA assumed (1) a standard 8-hour workday, (2) that the chemical is contacted at least once per day, and (3) that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials, dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of occupational dermal exposure. Also, EPA used dermal absorption data from tests performed on guinea pigs to estimate dermal exposure from liquids. Because guinea pigs have more permeable skin than humans (OECD, 2004c), the Agency is confident that using *in vitro* dermal absorption data from guinea pigs provide an upper-bound of dermal absorption of DBP.

Environmental and Exposure Pathways Considered in this Risk Evaluation

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

EPA assessed risks for acute, intermediate, and chronic exposure scenarios in workers (*i.e.,* those directly handling DBP) and ONUs for each OES. The Agency assumed that workers and ONUs would be individuals of both sexes (aged 16+ years, including pregnant workers) based upon occupational work permits. An objective of the assessment was to provide separate exposure level estimates for workers and ONUs. Dermal exposures were considered for all workers, but only considered for ONUs with potential exposure to dust or mist deposited on surfaces.

1 INTRODUCTION

1.1 Overview

This technical document supports the TSCA *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (also called "Draft Risk Evaluation for DBP") (U.S. EPA, 2025b) that was conducted under the Frank R. Lautenberg Chemical Safety for the 21st Century Act, which amended TSCA on June 22, 2016. The new law includes statutory requirements and deadlines for actions related to conducting risk evaluations of existing chemicals.

Under TSCA section 6(b), the U.S. Environmental Protection Agency (EPA or "the Agency") must designate chemical substances as high-priority substances for risk evaluation or low-priority substances for which risk evaluations are not warranted at the time, and upon designating a chemical substance as a high-priority substance, initiate a risk evaluation on the substance. TSCA section 6(b)(4) directs EPA to conduct risk evaluations for existing chemicals, 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 potentially exposed or susceptible subpopulation identified as relevant to the risk evaluation by the Administrator under the conditions of use."

TSCA section 6(b)(4)(D) and implementing regulations require that EPA publish the scope of the risk evaluation to be conducted, including the hazards, exposures, conditions of use (COUs), and PESS that the Administrator expects to consider, within 6 months after the initiation of a risk evaluation. In addition, a draft scope is to be published pursuant to 40 CFR 702.41. In December 2019, EPA published a list of 20 chemical substances that have been designated high priority substances for risk evaluations (EPA-HQ-OPPT-2019-0131) (84 FR 71924, December 30, 2019), as required by TSCA section 6(b)(2)(B), which initiated the risk evaluation process for those chemical substances. Dibutyl phthalate (DBP) is one of the chemicals designated as a high priority substance for risk evaluation.

DBP is a common chemical name for a chemical substance that includes the following names: dibutyl phthalate (CASRN 84-74-2), dibutyl benzene-1,2-dicarboxylate, 1,2-benzenedicarboxylic acid, dibutyl ester, di-n-butylorthophthalate, di-n-butyl phthalate. DBP is a low volatility liquid that is used primarily as a plasticizer in PVC, though it is also used in the production of adhesives, sealants, paints, coatings, rubbers, non-PVC materials, and other applications. All uses are subject to federal and state regulations and reporting requirements. DBP is a Toxics Release Inventory (TRI)-reportable substance, included on the TSCA Inventory, and reported under the Chemical Data Reporting (CDR) rule.

1.2 Scope

EPA assessed environmental releases and occupational exposures for conditions of use as described in Table 2-2 of the *Final Scope of the Risk Evaluation for Dibutyl Phthalate (DBP); CASRN 84-74-2* (also called the "final scope") (U.S. EPA, 2020b). To estimate environmental releases and occupational exposures, EPA first developed occupational exposure scenarios (OESs) related to the conditions of use of DBP. An OES is based on a set of facts, assumptions, and inferences that describe how releases and exposures take place within an occupational condition of use. The occurrence of releases/exposures may be similar across multiple conditions of use, or there may be several ways in which releases/exposures take place for a given condition of use. Table 1-1 shows mapping between the conditions of use in Table 2-2 of the *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025b) to the OESs assessed in this draft TSD.

In general, EPA mapped OESs to COUs using professional judgment based on available data and information. Several of the condition of use categories and subcategories were grouped and assessed together in a single OES due to similarities in the processes or lack of data to differentiate between them. This grouping minimized repetitive assessments. In other cases, condition of use subcategories were further delineated into multiple OESs based on expected differences in process equipment and associated release/exposure potentials between facilities. EPA assessed environmental releases and occupational exposures for the following OESs:

1. Manufacturing
2. Import and repackaging
3. Incorporation into formulations, mixtures, and reaction products
4. PVC plastics compounding
5. PVC plastics converting
6. Non-PVC material manufacturing (compounding and converting)
7. Application of adhesives and sealants
8. Application of paints and coatings
9. Industrial process solvent use
10. Use of laboratory chemicals
11. Use of lubricants and functional fluids
12. Use of penetrants and inspection fluids
13. Fabrication or use of final product or articles
14. Recycling
15. Waste handling, treatment, and disposal
16. Distribution in commerce

Table 1-1. Crosswalk of Conditions of Use Listed in the Draft Risk Evaluation to Assessed Occupational Exposure Scenarios

COU			OES(s)[d]
Life Cycle Stage[a]	**Category[b]**	**Subcategory[c]**	
Manufacturing	Domestic manufacturing	Domestic manufacturing	Manufacturing
	Importing	Importing	Import and repackaging
Processing	Repackaging	Laboratory chemicals in wholesale and retail trade; plasticizers in wholesale and retail trade; and plastics material and resin manufacturing	Import and repackaging
	Processing as a reactant	Intermediate in plastic manufacturing	Incorporation into formulations, mixtures, or reaction product
	Incorporation into formulation, mixture, or reaction product	Solvents (which become part of product formulation or mixture) in chemical product and preparation manufacturing; soap, cleaning compound, and toilet preparation manufacturing; adhesive manufacturing; and printing ink manufacturing	Incorporation into formulations, mixtures, or reaction product

COU			OES(s)[d]
Life Cycle Stage[a]	**Category[b]**	**Subcategory[c]**	
Processing	Incorporation into formulation, mixture, or reaction product	Plasticizer in paint and coating manufacturing; plastic material and resin manufacturing; rubber manufacturing; soap, cleaning compound, and toilet preparation manufacturing; textiles, apparel, and leather manufacturing; printing ink manufacturing; basic organic chemical manufacturing; and adhesive and sealant manufacturing	Incorporation into formulations, mixtures, or reaction product PVC plastics compounding; Non-PVC material manufacturing
		Pre-catalyst manufacturing	Incorporation into formulations, mixtures, or reaction product
	Incorporation into articles	Plasticizer in adhesive and sealant manufacturing; building and construction materials manufacturing; furniture and related product manufacturing; ceramic powders; plastics product manufacturing; and rubber product manufacturing	PVC plastics converting Non-PVC material manufacturing
	Recycling	Recycling	Recycling
Distribution in Commerce	Distribution in commerce		Distribution in commerce
Industrial Use	Non-incorporative activities	Solvent, including in maleic anhydride manufacturing technology	Industrial process solvent use
	Construction, paint, electrical, and metal products	Adhesives and sealants	Application of adhesives and sealants
		Paints and coatings	Application of paints and coatings
	Other uses	Automotive articles	Fabrication or use of final product or articles
		Lubricants and lubricant additives	Use of lubricants and functional fluids
		Propellants	Fabrication or use of final product or articles
Commercial Use	Automotive, fuel, agriculture, outdoor use products	Automotive care products	Use of lubricants and functional fluids
	Construction, paint, electrical, and metal products	Adhesives and sealants	Application of adhesives and sealants
		Paints and coatings	Application of paints and coatings
	Furnishing, cleaning, treatment care products	Cleaning and furnishing care products	Use of lubricants and functional fluids
		Floor coverings; construction and building materials covering large surface areas including stone, plaster, cement, glass and	Fabrication or use of final product or articles

COU			OES(s)[d]
Life Cycle Stage[a]	**Category[b]**	**Subcategory[c]**	
Commercial Use		ceramic articles; fabrics, textiles, and apparel	
		Furniture and furnishings	
	Packaging, paper, plastic, toys, hobby products	Ink, toner, and colorant products	Application of paints and coatings
		Packaging (excluding food packaging), including rubber articles; plastic articles (hard); plastic articles (soft); other articles with routine direct contact during normal use, including rubber articles; plastic articles (hard)	Fabrication or use of final product or articles
		Toys, playground, and sporting equipment	Fabrication or use of final product or articles
	Other uses	Laboratory chemicals	Use of laboratory chemicals
		Automotive articles	Fabrication or use of final product or articles
		Chemiluminescent light sticks	Fabrication or use of final product or articles
		Inspection penetrant kit	Use of Penetrants and Inspection Fluids
		Lubricants and lubricant additives	Use of lubricants and functional fluids
Disposal	Disposal	Disposal	Waste handling, treatment, and disposal

[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 Life Cycle Diagram, reflect CDR codes, and broadly represent COUs of DBP in industrial and/or commercial settings.

[c] These subcategories represent more specific activities within the life cycle stage and category of the COUs of DBP.

[d] An OES is based on a set of facts, assumptions, and inferences that describe how releases and exposures take place within an occupational COU. The occurrence of releases/exposures may be similar across multiple conditions of use (multiple COUs mapped to single OES), or there may be several ways in which releases/exposures take place for a given COU (single COU mapped to multiple OESs).

The assessment of releases includes quantifying annual and daily releases of DBP to air, water, and land. Releases to air include both fugitive and stack air emissions and emissions resulting from on-site waste treatment equipment, such as incinerators. For the purposes of this report, releases to water include both direct discharges to surface water and indirect discharges to publicly owned treatment works (POTW) or non-POTW wastewater treatment (WWT) plants. EPA considers removal efficiencies of POTWs and WWT plants as well as environmental fate and transport properties when evaluating risks from indirect discharges. Releases to land include any disposal of liquid or solid wastes containing DBP into landfills, land treatment, surface impoundments, or other land applications. The purpose of this module is to quantify releases; therefore, this report does not discuss downstream environmental fate and transport factors used to estimate exposures to the general population and ecological species. The *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025b) describes how these factors were considered when determining exposure and risk.

For workplace exposures, EPA considered exposures to both workers who directly handle DBP and occupational non-users (ONUs) who do not directly handle DBP, but may be exposed to dust, vapors or mists that enter their breathing zone while working in locations near DBP handling. EPA evaluated inhalation and dermal exposures to both workers and ONUs. EPA has performed a quantitative estimation on the effect of Personal Protective Equipment (PPE) on worker exposure risk estimates. The effect of PPE on occupational risk estimates is discussed in the *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025b) and the calculations can be found in the *Draft Risk Calculator for Occupational Exposures for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025a).

2 COMPONENTS OF AN ENVIRONMENTAL RELEASE AND OCCUPATIONAL EXPOSURE ASSESSMENT

EPA describes the assessed COUs for DBP in the Section 1.1.2 of the *Draft Risk Evaluation for Dibutyl Phthalate (DBP)* (U.S. EPA, 2025b); however, some COUs differ in terms of specific DBP processes and associated exposure/release scenarios. Therefore, Table 1-1 provides a crosswalk that maps the DBP COUs to the more specific OESs. The environmental release and occupational exposure assessments of each OES comprised the following components:

- **Process Description:** A description of the OES, including the function of the chemical in the scenario; physical forms and weight fractions of the chemical throughout the process; the total production volume associated with the OES; per site throughputs/use rates of the chemical; operating schedules; and process equipment used during the OES.
- **Facility Estimates:** An estimate of the number of sites that use DBP for the given OES.
- **Environmental Release Assessment**
    - **Environmental Release Sources:** A description of the potential sources of environmental releases in the process and their expected media of release for the OES.
    - **Environmental Release Assessment Results:** Estimates of DBP released into each environmental media (*i.e.*, surface water, POTW, non POTW-WWT, fugitive air, stack air, and each type of land disposal) for the given OES.
- **Occupational Exposure Assessment**
    - **Worker Activities:** A description of the worker activities, including an assessment of potential worker and ONU exposure points.
    - **Occupational Inhalation Exposure Results:** Central tendency and high-end estimates of inhalation exposures to workers and ONUs.
    - **Occupational Dermal Exposure Results:** Central tendency and high-end estimates of dermal exposures to workers and ONUs.
    - **Aggregate Exposure Results:** Aggregated central tendency and high-end estimates from the combination of dermal and inhalation exposures.

2.1 Approach and Methodology for Process Descriptions

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

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

Where DBP-specific process descriptions were unclear or not available, EPA referenced generic process descriptions from literature, including relevant Emission Scenario Documents (ESDs) or Generic Scenarios (GSs). Sections 3.1 through 3.16 provide process descriptions for each OES.

2.2 Approach and Methodology for Estimating Number of Facilities

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

1. Identify or "map" each facility that reported DBP in the 2020 CDR (U.S. EPA, 2020a), NEI (U.S. EPA, 2023a), DMR (U.S. EPA, 2024a), and TRI databases (U.S. EPA, 2024e) to an OES. Mapping consists of using facility reported industry sectors (typically reported as either North American Industry Classification System (NAICS) or Standard Industrial Classification (SIC) codes), chemical activity, and processing and use information to assign the most likely OES to each facility.
2. Based on the reporting thresholds and requirements of each data set, evaluate whether the data in the reporting programs is expected to cover most or all of the facilities within the OES. If so, the total number of facilities in the OES were assumed equal to the count of facilities mapped to the OES from each data set. If not, EPA proceeded to Step 3.
3. Supplement the available reporting data with U.S. economic and market data using the following steps:
    a. Identify the NAICS codes for the industry sectors associated with the OES.
    b. Estimate total number of facilities using the U.S. Census' Statistics of US Businesses (SUSB) data on total sites by 6-digit NAICS code.
    c. Use market penetration data to estimate the percentage of sites likely to be using DBP instead of other chemicals.
    d. Combine the data generated in Steps 3.a. through 3.c. to produce an estimate of the number of facilities using DBP in each 6-digit NAICS code and sum across all applicable NAICS codes to arrive at an estimate of the total number of facilities within the OES. Typically, it was assumed that this estimate encompassed the facilities identified in Step 1; therefore, the total number of facilities for the OES were assessed as the total generated from the analysis.
4. If market penetration data required for Step 3.c. are not available, EPA relied on generic industry data from GSs, ESDs, and other literature sources on typical throughputs/use rates, operating schedules, and the DBP production volume used within the OES to estimate the number of facilities. In cases where EPA identified a range of operating data in the literature for an OES, stochastic modeling was used to provide a range of estimates for the number of facilities within the OES. The approaches, equations, and input parameters used in stochastic modeling are described in the relevant OES sections throughout this report.

2.3 Environmental Releases Approach and Methodology

Releases to the environment were assessed using data obtained through direct measurement via monitoring, calculations based on empirical data, and/or assumptions and models. For each OES, EPA provided annual releases, high-end and central tendency daily releases, and the number of release days per year for each media of release (*i.e.*, air, water, and land).

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

1. Monitoring and measured data:
    a. Releases calculated from site- and media-specific concentration and flow rate data.

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

EPA described the final release results as either a point estimate (*i.e.*, a single descriptor or statistic, such as central tendency or high-end) or a full distribution. EPA considered three general approaches for estimating the final release result:

- Deterministic calculations: A combination of point estimates of each input parameter (*e.g.*, high-end and low-end values) were used to estimate central tendency and high-end release results. EPA documented the method and rationale for selecting parametric combinations representative of central tendency and high-end releases in the relevant OES subsections in Section 3.
- Probabilistic (stochastic) calculations: EPA ran Monte Carlo simulations using the statistical distribution for each input parameter to calculate a full distribution of the final release results. EPA selected the 50th and 95th percentiles of the resulting distribution to represent central tendency and high-end releases, respectively.
- Combination of deterministic and probabilistic calculations: EPA had statistical distributions for some parameters and point estimates for the remaining parameters. For example, EPA used Monte Carlo modeling to estimate annual throughputs and emission factors, but only had point estimates of release frequency and production volume. In this case, EPA documented the approach and rationale for combining point estimates with statistical distributions to estimate central tendency and high-end results in the relevant OES subsections in Sections 3.1 through 3.16.

2.3.1 Identifying Release Sources

EPA performed a literature search to identify process operations that could potentially result in releases of DBP to air, water, or land from each OES. For each OES, EPA identified the release sources and the associated media of release. Where DBP-specific release sources were unclear or unavailable, EPA referenced relevant ESDs or GSs. Sections 3.1 through 3.16 describe the release sources for each OES.

2.3.2 Estimating Number of Release Days

Unless EPA identified conflicting information, EPA assumed that the number of release days per year for a given release source equals the number of operating days at the facility. To estimate the number of operating days, EPA used the following hierarchy:

1. Facility-specific data: EPA used facility-specific operating days per year data, if available. Otherwise, EPA used data for other facilities within the same OES, if possible. EPA estimated the operating days per year using one of the following approaches:
   a. If other facilities have known or estimated average daily use rates, EPA calculated the days per year as follows: days/year = estimated annual use rate for the facility (kg/year) / average daily use rate from facilities with available data (kg/day).

    b. If facilities with days per year data do not have known or estimated average daily use rates, EPA used the average number of days per year from the facilities with available data.

2. Industry-specific data: EPA used industry-specific data from GSs, ESDs, trade publications, or other relevant literature.

3. Manufacture of large-production volume (PV) commodity chemicals: For the manufacture of large-PV commodity chemicals, EPA used a value of 350 days per year. This assumes the plant runs seven days per week and 50 weeks per year (with two weeks down for turnaround) and always produces the chemical.

4. Manufacture of lower-PV specialty chemicals: For the manufacture of lower-PV specialty chemicals, it is unlikely that the plant continuously manufactures the chemical throughout the year. Therefore, EPA used a value of 250 days per year. This assumes the plant manufactures the chemical five days per week and 50 weeks per year (with two weeks down for turnaround).

5. Other Chemical Plant OESs: For these OESs, EPA assumed that the facility does not always use the chemical of interest, even if the facility operates 24/7. Therefore, EPA used a value of 300 days/year, based on the assumption that the facility operates 6 days/week and 50 weeks/year (with two weeks for turnaround). However, in instances where the OES uses a low volume of the chemical of interest, EPA used 250 days per year as a lower estimate based on the assumption that the facility operates 5 days/week and 50 weeks/year (with two weeks for turnaround).

6. POTWs: Although EPA expects POTWs to operate continuously 365 days per year, the discharge frequency of the chemical of interest from a POTW will depend on the discharge patterns of the chemical from upstream facilities discharging to the POTW. However, there can be multiple upstream facilities (possibly with different OESs) discharging to the same POTW and information on when the discharges from each facility occur (*e.g.*, on the same day or separate days) is typically unavailable. Since EPA could not determine the exact number of days per year that the POTW discharges the chemical of interest, a value of 365 days per year was assumed.

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

2.3.3 Estimating Releases from Data Reported to EPA

Generally, EPA used the facility-specific release data reported in TRI, DMR, and NEI as annual releases in each data set for each site and estimated the daily release by averaging the annual release over the expected release days per year. EPA's approach to estimating release days per year is described in Section 2.3.2.

Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) established the TRI. TRI tracks the waste management of designated toxic chemicals from facilities within certain industry sectors. Facilities are required to report to TRI if the facility has 10 or more full-time employees; is included in an applicable NAICS code; and manufactures, processes, or uses the chemical in quantities greater than a certain threshold (25,000 pounds [lb] for manufacturers and processors of DBP and 10,000 lb for users of DBP). EPA makes the reported information publicly available through TRI. Each facility subject to the rule must report either using a Form R or a Form A. Facilities reporting using a Form R must report annually the volume of chemical released to the environment (*i.e.*, surface water, air, or land) and/or managed through recycling, energy recovery, and treatment (*e.g.*, incineration) from the facility. Facilities may submit a Form A if the volume of chemical manufactured, processed, or otherwise used does not exceed 1,000,000 pounds per year (lb/year) and the total annual reportable releases do not exceed 500 lb/year. Facilities reporting using Form A are not required to submit annual release and waste management volumes or use/sub-use information for the chemical. Due to reporting limitations, some sites that manufacture, process, or use DBP may not report to TRI and are therefore not included in EPA's assessment.

EPA included both TRI Form R and Form A submissions in the analysis of environmental releases. For Form Rs, EPA assessed releases using the reported annual release volumes from each media. For Form As, EPA estimated releases to each media using other approaches, where possible. Where no was approaches were available to estimate releases from facilities reporting using Form A's, EPA assessed releases using the 500 lb/year threshold for each release media; however, since this threshold is for total site releases, the 500 lb/year is attributed one release media (one or the other)—not all (to avoid over counting the releases and exceeding the total release threshold for Form A). For this draft risk evaluation, EPA used TRI data from reporting years 2017 to 2022 to provide a basis for estimating releases (U.S. EPA, 2022d). Further details on EPA's approach to using TRI data for estimating releases are described in Sections 2.3.3.1 through 2.3.3.3. In the assessment of releases for each OES, these assumptions and database limitations may lead to the estimated amount of DBP that is released from the manufacturing, processing, or use site to be under or overestimated. The methodology that sites use to estimate releases that are reported to TRI are also typically not fully described. These points may create some additional uncertainty in the assessment.

Under the Clean Water Act (CWA), EPA regulates the discharge of pollutants into receiving waters through National Pollutant Discharge Elimination System (NPDES). A NPDES permit authorizes discharging facilities to discharge pollutants to specified effluent limits. There are two types of effluent limits: (1) technology-based, and (2) water quality-based. While the technology-based effluent limits are uniform across the country, the quality-based effluent limits vary and are more stringent in certain areas. NPDES permits may also contain requirements for sewage sludge management.

NPDES permits apply pollutant discharge limits to each outfall at a facility. For risk evaluation purposes, EPA was interested only on the outfalls to surface water bodies. NPDES permits also include internal outfalls, but they aren't included in this analysis. This is because these outfalls are internal monitoring points within the facility wastewater collection or treatment system, so they do not represent discharges from the facility. NPDES permits require facilities to monitor their discharges and report the results to EPA and the state regulatory agency. Facilities report these results in DMRs. EPA makes these reported data publicly available via EPA's Enforcement and Compliance History Online (ECHO) system and EPA's Water Pollutant Loading Tool (Loading Tool). The Loading Tool is a web-based tool that obtains DMR data through ECHO, presents data summaries and calculates pollutant loading (mass of pollutant discharged). For this risk evaluation, EPA queried DMRs for all DBP point source water discharges available for 2017 to 2022 (U.S. EPA, 2022c). DMR only includes release data from NPDES permit holders, which affects the statistical representativeness of sites. The methodology that sites use to estimate releases that are reported to DMR are also typically not fully described. These points may create some additional uncertainty in the assessment. Further details on EPA's approach to using DMR data for estimating releases are described in Section 2.3.3.1.

The NEI was established to track emissions of Criteria Air Pollutants (CAPs) and CAP precursors and assist with National Ambient Air Quality Standard (NAAQS) compliance under the Clean Air Act (CAA). Air emissions data for the NEI are collected at the state, local, and tribal (SLT) level. SLT air agencies then submit these data to EPA through the Emissions Inventory System (EIS). In addition to

CAP data, many SLT air agencies voluntarily submit data for pollutants on EPA's list of HAPs. EPA uses the data collected from SLT air agencies, in conjunction with supplemental HAP data, to build the NEI. EPA makes an updated NEI publicly available every three years. For this risk evaluation, EPA used NEI data for reporting years 2017 and 2020 data to provide a basis for estimating releases (U.S. EPA, 2023a).

NEI emissions data are categorized into (1) point source data, (2) area or nonpoint source data, (3) onroad mobile source data, and (4) nonroad mobile source data. EPA included all four data categories in the assessment of environmental releases in this risk evaluation. Point sources are stationary sources of air emissions from facilities with operating permits under Title V of the CAA, also called "major sources." Major sources are defined as having actual or potential emissions at or above the major source thresholds. While thresholds can vary for certain chemicals in NAAQS non-attainment areas, the default threshold is 100 tons/year for non-HAPs, 10 tons per year for a single HAP, or 25 tons per year for any combination of HAPs. Point source facilities include large energy and industrial sites and are reported at the emission unit- and release point-level.

Area or nonpoint sources are stationary sources that do not qualify as major sources. The nonpoint data are aggregated and reported at the county-level and include emissions from smaller facilities as well as agricultural emissions, construction dust, and open burning. Industrial and commercial/institutional fuel combustion, gasoline distribution, oil and gas production and extraction, publicly owned treatment works, and solvent emissions may be reported in point or nonpoint source categories depending upon source size.

Onroad mobile sources include emissions from onroad vehicles that combust liquid fuels during operation, including passenger cars, motorcycles, trucks, and buses. The nonroad mobiles sources data include emissions from other mobile sources that are not typically operated on public roadways, such as locomotives, aircraft, commercial marine vessels, recreational equipment, and landscaping equipment. Onroad and nonroad mobile data are reported in the same format as nonpoint data; however, it is not available for every chemical. For DBP, onroad and nonroad mobile data are not available and was not used in the air release assessment. NEI only includes release data from units subject to NESHAP with threshold potential to emit, which affects the statistical representativeness of sites. The methodology that sites use to estimate releases that are reported to NEI are also typically not fully described. These points may create some additional uncertainty in the assessment. Further details on EPA's approach to using NEI data for estimating releases are described in Section 2.3.3.2.

2.3.3.1 Estimating Wastewater Discharges from TRI and DMR

Where available, EPA used TRI and DMR data from 2017 to 2022 to estimate annual wastewater discharges and the associated daily wastewater discharges. Reviewing data from the five-year span allowed EPA to perform a more thorough analysis and generate medians and maximums for sites that reported over multiple years.

Annual Wastewater Discharges

For TRI, annual discharges are reported directly by facilities. For DMR, annual discharges are automatically calculated by the Loading Tool based on the sum of the discharges associated with each monitoring period in DMR. Monitoring periods in DMR are set by each facility's NPDES permit and can vary between facilities. Typical monitoring periods in DMR include monthly, bimonthly, quarterly, semi-annual, and annual reporting. In instances where a facility reports a period's monitoring results as below the limit of detection (LOD) (also referred to as a non-detect or ND) for a pollutant, the Loading Tool applies a hybrid method to estimate the wastewater discharge for the period. The hybrid method sets the values to half of the LOD if there was at least one detected value in the facility's DMRs in a calendar year. If all values were less than the LOD in a calendar year, the annual load is set to zero.

Average Daily Wastewater Discharges

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

1. Obtain total annual loads calculated from the Loading Tool and reported annual direct surface water discharges and indirect discharges to POTW and non-POTW WWT in TRI.
2. For TRI reporters using a Form A, estimate annual releases using an alternative approach (see Sections 2.3.4 and 2.3.5) or at the threshold of 500 lb per year.
3. Determine if any of the facilities receiving indirect discharges reported in TRI have reported DMRs for the corresponding TRI reporting year, if so, exclude these indirect discharges from further analysis. The associated surface water release (after any treatment at the receiving facility) will be incorporated as part of the receiving facility's DMR.
4. Divide the annual discharges by the number of estimated operating days (estimated as described in Section 2.3.2).

2.3.3.2 Estimating Air Emissions from TRI and NEI

Where available, EPA used TRI data from 2017 to 2022 and NEI data from 2017 and 2020 to estimate annual and average daily fugitive and stack air emissions. For air emissions, EPA estimated both release patterns (*i.e.*, days per year of release) and release durations (*i.e.*, hours per day the release occurs). Reviewing data from multiple years allowed EPA to perform a more thorough analysis and generate medians and maximums for sites that reported more than once in that time span,

Annual Emissions

Facility-level annual emissions are available for TRI reporters and major sources in NEI. EPA used the reported annual emissions directly as reported in TRI and NEI for major sources. NEI also includes annual emissions for area sources that are aggregated at the county-level. Area source data in NEI is not divided between sites or between stack and fugitive sources. Therefore, EPA only presented annual emissions for each county-OES combination.

Average Daily Emissions

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

1. Obtain total annual fugitive and stack emissions for each TRI reporter and major source in NEI.
2. For TRI reporters using a Form A, estimate annual releases using an alternative approach (see Sections 2.3.4 and 2.3.5) or at the threshold of 500 lb per year.
3. Divide the annual stack and fugitive emissions over the number of estimated operating days (note: NEI data includes operating schedules for many facilities that can be used to estimate facility-specific days per year).
4. Estimate a release duration using facility-specific data available in NEI, models, and/or literature sources. If no data are available, list as "unknown."

To estimate average daily emissions from area sources, EPA followed a very similar approach as described for TRI reporters and major sources in NEI; however, area source data in NEI is not divided between sites or between stack and fugitive sources. Area data also does not include release duration data as the emissions are aggregated at the county-level rather than facility level. Therefore, EPA only presented annual emissions for each county-OES combination.

2.3.3.3 Estimating Land Disposals from TRI

Where available, EPA used TRI data from 2017 to 2022 to estimate annual and average daily land disposal volumes. TRI includes reporting of disposal volumes for a variety of land disposal methods, including but not limited to underground injection, RCRA Subtitle C landfills, land treatment, RCRA Subtitle C surface impoundments, other surface impoundments, and other land disposal. EPA provided estimates for both a total aggregated land disposal volume and disposal volumes for each disposal method reported in TRI. Reviewing data from the 5-year span allowed the Agency to perform a more thorough analysis and generate medians and maximums for sites that reported over multiple years.

Annual Land Disposal

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

Average Daily Land Disposal

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

1. Obtain total annual disposal volumes for each land disposal method for each TRI reporter.
2. For TRI reporters using a Form A, estimate annual releases using an alternative approach (see Sections 2.3.4 and 2.3.5) or at the threshold of 500 lb per year.
3. Divide the annual disposal volumes for each land disposal method over the number of estimated operating days.
4. Combine totals from all land disposal methods from each facility to estimate a total aggregate disposal volume to land.

2.3.4 Estimating Releases from Models

EPA utilized models to estimate environmental releases for OESs without TRI, DMR, or NEI data. These models apply deterministic calculations, stochastic calculations, or a combination to estimate releases. EPA used the following steps to estimate releases:

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

For release models that utilized stochastic calculations, EPA performed a Monte Carlo simulation using the Palisade Risk Version 8.0.0 software with 100,000 iterations and the Latin Hypercube sampling method (Palisade, 2022). Appendix D provides detailed descriptions of the model approaches that EPA used for each OES as well as model equations, input parameter values, and associated distributions.

For some modeled releases, the media of release is dependent on site- and process-specific practices that are unknown. To account for this uncertainty, these release estimates may be assessed to groups of multiple release medias based on the release point and the chemical's physical form (*i.e.*, water, incineration, or landfill or air, water, incineration, or landfill) to account for all possible chemical waste endpoints.

2.3.5 Estimating Releases Using Literature Data

Where available, EPA used data from literature sources to assist in assessing releases. Literature data for this assessment primarily was used for information related to release modeling. When industry- or chemical-specific emission factors are available, EPA may use these emission factors to calculate releases for an OES or incorporate the emission factors into release models to develop a distribution of potential releases for the OES. Sections 3.1 through 3.16 provides a detailed description of how EPA incorporated literature data into the release estimates for each OES.

2.4 Occupational Exposure Approach and Methodology

For workplace exposures, EPA considered exposures to both workers who directly handle DBP and ONUs who do not directly handle DBP but may be exposed to vapors, particulates, or mists that enter their breathing zone while working in locations near DBP handling. EPA evaluated inhalation and dermal exposures to both workers and ONUs.

EPA provided occupational exposure results representative of central tendency and high-end exposure conditions. The central tendency is expected to represent occupational exposures in the center of the distribution for a given COU. For risk evaluation, EPA used the 50th percentile (median), mean (arithmetic or geometric), mode, or midpoint values of a distribution as representative of the central tendency scenario. EPA preferred to provide the 50th percentile of the distribution. However, if the full distribution is unknown, EPA may assume that the mean, mode, or midpoint of the distribution represents the central tendency depending on the statistics available for the distribution.

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

For occupational exposures, EPA used measured or estimated air concentrations to calculate exposure concentration metrics required for risk assessment, such as average daily concentration (ADC). These calculations require additional parameter inputs, such as years of exposure, exposure duration and exposure frequency. EPA estimated exposure concentrations from monitoring data, modeling, or occupational exposure limits.

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

- Deterministic calculations: EPA used combinations of point estimates of each parameter to estimate a central tendency and high-end for each final exposure metric result.
- Probabilistic (stochastic) calculations: EPA used Monte Carlo simulations using the full distribution of each parameter to calculate a full distribution of the final exposure metric results and selecting the 50th and 95th percentiles of this resulting distribution as the central tendency and high-end, respectively.

- Combination of deterministic and probabilistic calculations: EPA had full distributions for some parameters but point estimates of the remaining parameters. For example, the Agency used Monte Carlo modeling to estimate exposure concentrations, but only had point estimates of exposure duration and frequency.

Appendix A discusses the equations and input parameter values that EPA used to estimate each exposure metric.

For each OES, EPA provided high-end and central tendency, full-shift, time-weighted average (TWA) (typically as an 8-hour TWA) inhalation exposure concentrations as well as high-end and central tendency acute potential dermal dose rates (APDR). EPA applied the following hierarchy in selecting data and approaches for assessing occupational exposures:

- Monitoring data:
    a. Personal and directly applicable to the OES
    b. Area and directly applicable to the OES
    c. Personal and potentially applicable or similar to the OES
    d. Area and potentially applicable or similar to the OES
- Modeling approaches:
    a. Surrogate monitoring data
    b. Fundamental modeling approaches
    c. Statistical regression modeling approaches
- Occupational exposure limits:
    a. Company-specific occupational exposure limits (OELs) (for site-specific exposure assessments; for example, there is only one manufacturer who provides their internal OEL to EPA, but the manufacturer does not provide monitoring data)
    b. Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs)
    c. Voluntary limits (*i.e.*, American Conference of Governmental Industrial Hygienists [ACGIH] Threshold Limit Values [TLV]; National Institute for Occupational Safety and Health [NIOSH] Recommended Exposure Limits [RELs]; Occupational Alliance for Risk Science (OARS) workplace environmental exposure level (WEELs) [formerly by AIHA])

EPA used the estimated high-end and central tendency, full-shift TWA inhalation exposure concentrations and APDR to calculate the exposure metrics required for risk evaluation. Exposure metrics for inhalation and dermal exposures include acute dose (AD), intermediate average daily dose (IADD), and average daily dose (ADD). Appendix A describes the approach that EPA used to estimating each exposure metric.

2.4.1 Identifying Worker Activities

EPA performed a literature search and reviewed data from systematic review to identify worker activities that could potentially result in occupational exposures. Where worker activities were unclear or not available, EPA referenced relevant ESDs or GSs. Section 3 provides worker activities for each OES.

2.4.2 Estimating Inhalation Exposures

2.4.2.1 Inhalation Monitoring Data

To assess inhalation exposure, EPA reviewed workplace inhalation monitoring data collected by government agencies such as OSHA and NIOSH, monitoring data found in published literature (*i.e.*, personal exposure monitoring data and area monitoring data), and monitoring data submitted via public comments. Studies were evaluated using the strategies presented in the *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2021a).

EPA calculated exposures from the monitoring datasets provided in the sources discussed above, using different methodologies depending on the size of the dataset. For datasets with six or more data points, The Agency estimated central tendency and high-end exposures using the 50th and 95th percentile values, respectively. For datasets with three to five data points, EPA estimated the central tendency and high-end exposures using the 50th percentile and maximum values, respectively. For datasets with two data points, the Agency presented the midpoint and the maximum value. Finally, EPA presented datasets with only one data point as-is. For datasets that included exposure data reported as below the limit of detection (LOD), EPA estimated exposure concentrations following guidance in EPA's *Guidelines for Statistical Analysis of Occupational Exposure Data* (U.S. EPA, 1994). That report recommends using the $\frac{LOD}{\sqrt{2}}$ if the geometric standard deviation of the data is less than 3.0 and $\frac{LOD}{2}$ if the geometric standard deviation is 3.0 or greater.

If the 8-hour TWA personal breathing zones (PBZ) monitoring samples were not available, area samples were used for exposure estimates. EPA combined the exposure data from all studies applicable to a given OES into a single dataset.

For each COU, EPA endeavors to distinguish exposures for workers and ONUs. Normally, a primary difference between workers and ONUs is that workers may handle DBP and have direct contact with the chemical, while ONUs are working in the general vicinity of workers but do not handle DBP and do not have direct contact with DBP being handled by the workers. Generally, potential exposures to ONUs are expected to be less than workers since they may not be exposed to the chemical for an entire 8-hour workday. EPA recognizes that worker job titles and activities may vary significantly from site to site; therefore, the Agency typically identified samples as worker samples unless it was explicitly clear from the job title (*e.g.*, inspectors) and the description of activities in the report that the employee was not directly involved in the scenario. Samples from employees determined not to be directly involved in the scenario were designated as ONU samples.

OSHA Chemical Exposure Health Data

OSHA Chemical Exposure Health Data (CEHD) is collected through industrial hygiene samples taken by OSHA compliance officers during monitoring of worker exposures to chemical hazards. OSHA CEHD data is obtained typically from facilities when there is suspicion about high workplace exposure levels or potential violations. OSHA CEHD represents a reasonably available source of information to obtain monitoring data and has received a rating of high from EPA's systematic review process. Air sampling data records from inspections are entered into the OSHA CEHD that can be accessed online. The database includes PBZ monitoring data, area monitoring data, bulk samples, wipe samples, and serum samples. The collected samples are used for comparing to OSHA's PELs and STELs. OSHA's CEHD website indicates that they do not (1) perform routine inspections at every business that uses toxic/hazardous chemicals, (2) completely characterize all exposures for all employees every day, or (3) always obtain a sample for an entire shift. Rather, OSHA performs targeted inspections of certain industries based on national and regional emphasis programs, often attempts to evaluate worst case chemical exposure scenarios, and develops "snapshots" of chemical exposures and assess their significance (*e.g.*, comparing measured concentrations to the regulatory limits).

EPA took the following approach to analyzing OSHA CEHD:

1. Downloaded monitoring data for DBP from 1992 to 2022: See Section 2.6 for evidence integration notes on targeted years.
2. Organized data by site: (*i.e.*, grouped data collected at the same site together).
3. Removed serum samples, bulk samples, wipe samples, and blanks: These data are not used in EPA's assessment.
4. Assigned each data point to an OES: Review NAICS codes, SIC codes, and as needed, company information available online, to map each sample to an OES. In some instances, EPA was unable to determine the OES from the information in the CEHD; in such cases, the Agency did not use the data in the assessment. EPA also removed data determined to be likely for non-TSCA uses or otherwise out of scope.
5. Combined samples from the same worker: In some instances, OSHA inspectors will collect multiple samples from the same worker on the same day (these are indicated by sample ID numbers). In these cases, EPA combined results from all samples for a particular sample ID to construct an exposure concentration based on the totality of exposures from each worker.
6. Calculated 8-hour TWA results from combined samples: Where the total sample time was less than 8 hours (480 minutes), but greater than 330 minutes, EPA calculated an 8-hour TWA by assuming exposures were zero for the remainder of the shift. For any calculated 8-hour TWA exposures that were equal to zero or non-detects, the Agency replaced this value with the LOD divided by either two or the square root of two (see step 7). EPA did consider all samples for 8-hour TWA that were marked "eight-hour calculation used" in the OSHA CEHD database with no adjustment.

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

Specific details related to the use of monitoring data for each COU can be found in Sections 3.1.4 through 3.15.4.

2.4.2.2 Inhalation Exposure Modeling

Where inhalation exposures are expected for an OES but monitoring data were unavailable, EPA utilized models (See Appendix D) to estimate inhalation exposures. These models apply deterministic calculations, stochastic calculations, or a combination of both deterministic and stochastic calculations to estimate inhalation exposures. EPA used the following steps to estimate exposures for each OES:

1. Identify worker activities and potential sources of exposures from each process.
2. Identify or develop model equations for estimating exposures from each source.
3. Identify model input parameter values from relevant literature sources, including activity durations associated with sources of exposures.
4. If a range of input values is available for an input parameter, determine the associated distribution of input values.
5. Calculate exposure concentrations associated with each activity.
6. Calculate full-shift TWAs based on the exposure concentration and activity duration associated with each exposure source.
7. Calculate exposure metrics (AD, IADD, ADD) from full-shift TWAs.

For exposure models that utilize stochastic calculations, EPA performed a Monte Carlo simulation using the Palisade @Risk Version 8.0.0 software with 100,000 iterations and the Latin Hypercube sampling method (Palisade, 2022). Appendix D provides detailed descriptions of the model approaches used for each OES, model equations, and input parameter values and associated distributions.

2.4.3 Estimating Dermal Exposures

This section summarizes the available dermal absorption data related to DBP (Section 2.4.3.1), the interpretation of the dermal absorption data (Section 2.4.3.2), dermal absorption modeling efforts (Section 2.4.3.3), and uncertainties associated with dermal absorption estimation (Section 2.4.3.4). Dermal data were sufficient to characterize occupational dermal exposures to liquids or formulations containing DBP (Section 2.4.3.1); however, dermal data were not sufficient to estimate dermal exposures to solids or articles containing DBP. Therefore, modeling efforts described in Section 2.4.3.3 were utilized to estimate dermal exposures to solids or articles containing DBP. Dermal exposures to vapors are not expected to be significant due to the extremely low volatility of DBP; therefore, they are not included in the dermal exposure assessment of DBP.

2.4.3.1 Dermal Absorption Data

Dermal absorption data related to DBP were identified in scientific literature. EPA identified six studies directly related to the dermal absorption of DBP. Of the six available studies, EPA identified one study that was most reflective of DBP exposure from liquid products and formulation (Doan et al., 2010). The study received a rating of medium from EPA's systematic review process.

- Relatively recent studies were preferred as applicable to modern dermal testing techniques and guidelines for *in vivo* and *in vitro* dermal absorption studies (*i.e.*, OECD Guideline 427 (OECD, 2004c) and Guideline 428 (OECD, 2004d)).
- Studies of human skin were preferred over animal models, and when studies with human skin were not suitable (see other criteria), animal skin studies were preferred in this order, guinea pig over rat studies.
- Studies of split skin thickness were preferred over studies of full thickness. Generally, studies should provide information on dermatoming methods and ideally provide a value for thickness in accordance with OECD guideline 428 (OECD, 2004d), which recommends a range of 400 to 800 µm or less than 1 mm.
- Freshly excised (non-frozen) skin studies were preferred, if there was not a significant delay between skin sample retrieval and assay initiation.
- Studies using an aqueous vehicle type were preferred over neat chemical studies as there is greater relevance to commercial product formulations and subsequent exposure and due to greater uncertainties from neat chemical resulting in lower absorptions than formulations which may enhance dermal absorption.
- Studies with reported sample temperatures that represent human body temperature, in a humidity-controlled environment were preferred.

Doan et al. (2010) conducted *in vivo* and *in vitro* experiments in female hairless guinea pigs to compare absorption measurements using the same dose of DBP. Compared to other dermal studies, skin samples used in this study (Doan et al., 2010) were the most relevant and appropriate as they were exposed to a formulation of 7 percent oil-in-water emulsion which was preferable over neat chemical. The physical state of pure DBP is an oily liquid that is similar to an emulsion. In the *in vitro* experiments, skin was excised from the animals (anatomical site of the tissue collections was not specified) and radiolabeled DBP (1 mg/m^2) was applied to a split thickness skin preparation (200 µm) for 24 or 72 hours. Absorption was measured every 6 hours in a flow-through chamber. The test system was un-occluded, and skin was washed prior to application. Though certain aspects of the experiment were not reported, overall, the study complies with OECD guideline 428 (OECD, 2004d)). A total of 56.3 percent of the administered dose was absorbed in the *in vitro* experiment; the percent total recovery was 96.3 percent of the administered dose.

In the *in vivo* experiment (2010), female hairless guinea pigs were given a single dermal application via covered patch (3 x 3-centimeter square area; 9 cm^2) of an oil-in-water emulsion containing 1 mg/cm^2 DBP. The chemical was applied to the mid-scapular region of the guinea pig back, although it is unclear if this represents 10 percent of the animal body surface. The amount of DBP absorption was measured in the skin, urine, feces, blood, and tissues. The *in vivo* dermal absorption of DBP was estimated to be approximately 62 percent of the applied dose after 24 hours. The percent total recovery was 92.9 percent after 24 hours. Total penetration was reported to be 65.4 percent and included total systemic absorption plus skin absorption, and recovery of materials in skin around the dosing site, which is in agreement with the 24-hour *in vitro* experiment findings. The outcomes assessment method mostly agreed with guideline OECD 427 (OECD, 2004c).

2.4.3.2 Flux-Limited Dermal Absorption for Liquids

Dermal absorption data from Doan et al. (2010) showed 56.3 percent absorption of 1 mg/cm^2 of DBP over a 24-hour period, resulting in an average absorptive flux of DBP of 2.35×10^{-2} $mg/cm^2/h$. EPA assumed that the average absorptive flux from Doan et al. (2010) is representative of the average absorptive flux over the period of a workday for purposes of dermal exposure estimation in occupational settings.

The estimated steady-state fluxes of DBP presented in this section, based on the results of Doan et al. (2010), is representative of exposures to liquid materials or formulations only. Dermal exposures to liquids containing DBP are described in this section. Regarding dermal exposures to solids containing DBP, there were no available data and dermal exposures to solids are modeled as described in Section 2.4.3.3.

EPA selects Doan et al. (2010) as a representative study for dermal absorption to liquids. Doan et al. (2010) is a relatively recent study in guinea pigs, and it uses a formulation consisting of 7 percent oil-in-water which is preferred over studies that use neat chemicals. Two other older *in vivo* studies were considered: Elsisi et al. (1989) and Janjua et al. (2008). Elsisi et al. (1989) provided data on the dermal absorption of DBP by measuring the percentage of dose excreted in the urine and feces of rats daily over a 7-day exposure. EPA considers more recent data (2010 vs. 1989) and study duration (24 hours vs. 7 days) from Doan et al. (2010) to be more appropriate and representative to TSCA dermal scenarios. The third *in vivo* study, Janjua et al. (2008), applied cream with a 2 percent DBP formulation to the skin of human participants daily for 5 days. This study measured the metabolite of DBP, MBP, in urine, however this study had significant limitations including a very large inter-individual variability in absorption values and daily variations in values for the same individual. Two additional *ex vivo* studies, Scott et al. (1987) and Sugino et al. (2017) noted DBP to be more readily absorbed in rat skin versus human skin. These *ex vivo* studies suggest that human skin and rat skin are not directly comparable, with the 1987 study providing evidence of a two-magnitude greater absorption rate in rat skin compared to human skin.

2.4.3.3 Flux-Limited Dermal Absorption for Solids

Because DBP has low volatility and relatively low absorption, the dermal absorption of DBP was estimated based on the flux of material rather than percent absorption. For cases of dermal absorption of DBP from a solid matrix, EPA assumes that DBP first migrates from the solid matrix to a thin layer of moisture on the skin surface. Therefore, absorption of DBP from solid matrices is considered limited by aqueous solubility and is estimated using an aqueous absorption model as described below.

The first step in modeling dermal absorption through aqueous media is to estimate the steady-state permeability coefficient, K_p (cm/h). EPA utilized the Consumer Exposure Model (CEM) (U.S. EPA, 2023b) to estimate the steady-state aqueous permeability coefficient of DBP as 0.017 cm/h. Next, EPA relied on Equation 3.2 from the *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, (Part E: Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA, 2004b) which characterizes dermal uptake (through and into skin) for aqueous organic compounds. Specifically, Equation 3.2 from U.S. EPA (2004b), also shown in Equation 2-1 below, was used to estimate the dermally absorbed dose (DA_{event}, mg/cm^2) for an absorption event occurring over a defined duration (t_{abs}).

Equation 2-1. Dermal Absorption Dose During Absorption Event

$$DA_{event} = 2 \times FA \times K_p \times S_W \times \sqrt{\frac{6 \times t_{lag} \times t_{abs}}{\pi}}$$

Where:

DA_{event}	=	Dermally absorbed dose during absorption event t_{abs} (mg/cm^2)
FA	=	Effect of stratum corneum on quantity absorbed = 0.9 (see Exhibit A-5 of U.S. EPA (2004b)] and confirmed by Doan et al. (2010) for 0.87)
K_p	=	Permeability coefficient = 0.017 cm/h (calculated using CEM (U.S. EPA, 2023b))
S_w	=	Water solubility =11.2 mg/L (see DBP Physical and Chemical Properties TSD)
t_{lag}	=	$0.105*10^{0.0056MW} = 0.105*10^{0.0056*278.35}$ = 3.80 hours (calculated from A.4 of U.S. EPA (2004b))
t_{abs}	=	Duration of absorption event (hours)

By dividing the dermally absorbed dose (DA_{event}) by the duration of absorption (t_{abs}), the resulting expression yields the average absorptive flux. Figure 2-1 illustrates the relationship between the average absorptive flux and the absorption time.

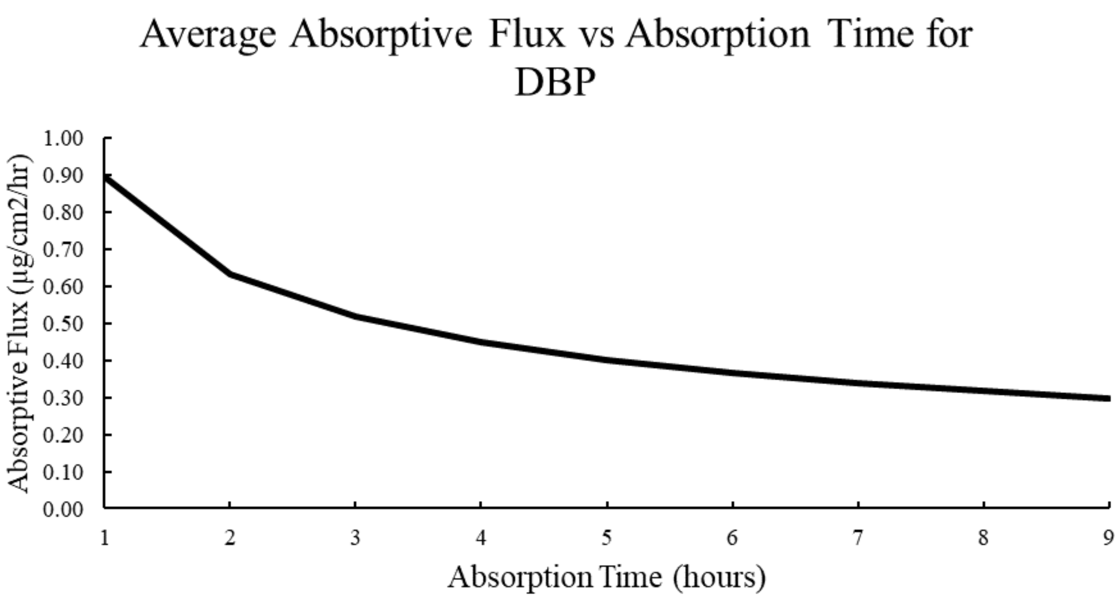


Figure 2-1. DBP Average Absorptive Flux vs. Absorption Time

Using Equation 3.2 from the *Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual, (Part E: Supplemental Guidance for Dermal Risk Assessment)* (U.S. EPA, 2004b), which characterizes dermal uptake (through and into skin) for aqueous organic compounds, EPA estimates the flux of DBP to be 0.89 and 0.32 μg/cm^2/h at 1 and 8 hours, respectively. EPA assumed that the flux was constant over the absorption time and estimated the average absorptive flux of 0.32 μg/cm^2/h.

2.4.3.4 Uncertainties in Dermal Absorption Estimation

As noted above in Section 2.4.3.1, EPA identified six studies directly related to the dermal absorption of DBP; one study was determined to be most representative of DBP exposure from liquid products and formulations (Doan et al., 2010). This dermal absorption study was conducted *in vitro* and *in vivo* using female guinea pigs. There have been additional studies conducted to determine the difference in dermal absorption between animal skin and human skin. Specifically, Scott (1987) examined the difference in dermal absorption between rat skin and human skin for four different phthalates (*i.e.*, DMP, DEP, DBP, and DEHP) using *in vitro* dermal absorption testing. Results from the *in vitro* dermal absorption experiments showed that rat skin was more permeable than human skin for all four phthalates examined. For example, rat skin was up to 100 times more permeable than human skin for DBP, 30 times more permeable than human skin for DEP, and rat skin was up to 4 times more permeable than human skin for DEHP. OECD guidelines indicate that guinea pig tissue is more similar to human skin than rat tissue (OECD, 2004c). Though there is uncertainty regarding the magnitude of difference between dermal absorption through guinea pig skin vs. human skin for DBP, EPA is confident that the dermal absorption data using female guinea pigs (Doan et al., 2010) provides an upper-bound of dermal absorption of DBP based on the findings of Scott (1987).

Another source of uncertainty regarding the dermal absorption of DBP from products or formulations stems from the varying concentrations and co-formulants that exist in products or formulations containing DBP. For purposes of this risk evaluation, EPA assumes that the absorptive flux of 7 percent oil-in-water formulation of DBP measured from guinea pig experiments serves as a conservative representative estimate of the potential absorptive flux of chemical into and through the skin for dermal contact with all liquid products or formulations, and that the modeled absorptive flux of aqueous DBP serves as an upper-bound of potential absorptive flux of chemical into and through the skin for dermal contact with all solid products. Dermal contact with products or formulations that have lower concentrations of DBP may exhibit lower rates of flux since there is less material available for absorption. Conversely, co-formulants or materials within the products or formulations may lead to enhanced dermal absorption, even at lower concentrations. Therefore, it is uncertain whether the products or formulations containing DBP at different concentrations than studied in Doan et al. (2010) would result in decreased or increased dermal absorption. Additionally, it is unclear how representative the data from Doan et al. (2010) are for neat DBP.

Lastly, EPA notes that there is uncertainty with respect to the modeling of dermal absorption of DBP from solid matrices or articles. Because there were no available data related to the dermal absorption of DBP from solid matrices or articles, EPA has assumed that dermal absorption of DBP from solid objects would be limited by aqueous solubility of DBP. Therefore, to determine the maximum steady-state aqueous flux of DBP, EPA utilized CEM (U.S. EPA, 2023b) to first estimate the steady-state aqueous permeability coefficient of DBP. The estimation of the steady-state aqueous permeability coefficient within CEM (U.S. EPA, 2023b) is based on quantitative structure-activity relationship (QSAR) model presented by ten Berge (2009), which considers chemicals with $\log(K_{ow})$ ranging from −3.70 to 5.49 and molecular weights ranging from 18 to 584.6. The $\log(K_{ow})$ and molecular weight of DBP (4.5 and 278.35 g/mol, respectively) fall within the range suggested by ten Berge (2009). Therefore, EPA is confident regarding the accuracy of the QSAR model used to predict the steady-state aqueous permeability coefficient for DBP based on both parameters falling within the suggested ranges.

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

For each COU, the estimated exposures were used to calculate acute, intermediate, and chronic (non-cancer) inhalation and dermal doses. These calculations require additional parameter inputs, such as years of exposure, exposure duration and exposure frequency.

For the final exposure result metrics, each of the input parameters (*e.g.*, air concentrations, dermal doses, working years, exposure frequency) may be a point estimate (*i.e.*, a single descriptor or statistic, such as central tendency or high-end) or a full distribution. As described in Section 2.4, EPA considered three general approaches for estimating the final exposure result metrics: deterministic calculations, probabilistic (stochastic) calculations, and a combination of deterministic and probabilistic calculations. Equations for these exposures can be found in Appendix A.

2.5 Consideration of Engineering Controls and Personal Protective Equipment

This section contains general information on engineering controls and personal protective equipment. EPA has performed a quantitative estimation on the effect of personal protective equipment (PPE) on worker exposure. The effect of PPE on occupational risk estimates is discussed in the Draft Risk Evaluation for DBP (U.S. EPA, 2025b) and the calculations can be found in the Draft Risk Calculator for Occupational Exposures for DBP (U.S. EPA, 2025a).

Occupational Safety and Health Adminstration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) recommend employers utilize the hierarchy of controls[1] to address hazardous exposures in the workplace. The hierarchy of controls strategy outlines, in descending order of priority, the use of elimination, substitution, engineering controls, administrative controls, and lastly PPE. The hierarchy of controls prioritizes the most effective measures, which eliminate or substitute the harmful chemical (*e.g.*, use a different process, substitute with a less hazardous material), thereby preventing or reducing exposure potential. Following elimination and substitution, the hierarchy recommends engineering controls to isolate employees from the hazard, followed by administrative controls or changes in work practices to reduce exposure potential (*e.g.*, source enclosure, local exhaust ventilation systems). Administrative controls are policies and procedures instituted and overseen by the employer to protect worker exposures. OSHA and NIOSH recommend the use of PPE (*e.g.*, respirators, gloves) as the last means of control, when the other control measures cannot reduce workplace exposure to an acceptable level.

2.5.1 Respiratory Protection

OSHA's Respiratory Protection Standard (29 CFR 1910.134) requires employers in certain industries to address workplace hazards by implementing engineering control measures and, if these are not feasible, providing respirators that are applicable and suitable for the purpose intended. Respirator selection provisions are provided in section 1910.134(d) and require that appropriate respirators be selected based on the respiratory hazard(s) to which the worker will be exposed, in addition to workplace and user factors that affect respirator performance and reliability. Assigned protection factors (APFs) are provided in Table 1 under section 1910.134(d)(3)(i)(A) (see below in Table 2-1) and refer to the level of respiratory protection that a respirator or class of respirators is expected to provide to employees when

[1] See https://www.osha.gov/sites/default/files/Hierarchy_of_Controls_02.01.23_form_508_2.pdf.

the employer implements a respiratory protection program according to the requirements of OSHA's Respiratory Protection Standard.

Workers are required to use respirators that meet or exceed the required level of protection listed in Table 2-1. Based on the APF, inhalation exposures may be reduced by a factor of 5 to 10,000, if respirators are properly worn and fitted.

Table 2-1. Assigned Protection Factors for Respirators in OSHA Standard 29 CFR 1910.134

Type of Respirator	Quarter Mask	Half Mask	Full Facepiece	Helmet/ Hood	Loose-Fitting Facepiece
1. Air-purifying respirator	5	10	50	–	–
2. Power air-purifying respirator (PAPR)	–	50	1,000	25/1,000	25
3. Supplied-air respirator (SAR) or airline respirator					
• Demand mode	–	10	50	–	–
• Continuous flow mode	–	50	1,000	25/1,000	25
• Pressure-demand or other positive-pressure mode	–	50	1,000	–	–
4. Self-contained breathing apparatus (SCBA)					
• Demand mode	–	10	50	50	–
• Pressure-demand or other positive-pressure mode (*e.g.*, open/closed circuit)	–	–	10,000	10,000	–
Source: 29 CFR 1910.134(d)(3)(i)(A)					

2.5.2 Glove Protection

Gloves are selected in industrial settings based on characteristics (permeability, durability, required task etc). Data on the frequency of glove use (*i.e.*, the proper use of effective gloves) in industrial settings is very limited. An initial literature review suggests that there is unlikely to be sufficient data to justify a specific probability distribution for effective glove use for handling of DBP specifically, for a given industry. Instead, EPA explored the impact of effective glove use by considering different percentages of effectiveness (*e.g.*, 25 vs. 50% effectiveness).

Gloves only offer barrier protection until the chemical breaks through the glove material. Using a conceptual model, Cherrie (2004) proposed a glove workplace protection factor, defined as the ratio of estimated uptake through the hands without gloves to the estimated uptake though the hands while wearing gloves. This protection factor is driven by flux, and thus the protection factor varies with time. The ECETOC TRA Model v.3.2 represents the glove protection factor as a fixed, assigned value equal to 5, 10, or 20 (Marquart et al., 2017). Like the APR for respiratory protection, the inverse of the protection factor is the fraction of the chemical that penetrates the glove. Table 2-2 presents glove protection factors for different dermal protection characteristics.

Table 2-2. Glove Protection Factors for Different Dermal Protection Strategies

Dermal Protection Characteristics	Setting	Protection Factor (PF)
a. No gloves used, or any glove/gauntlet without permeation data and without employee training	Industrial and Commercial Uses	1
b. Gloves with available permeation data indicating that the material of construction offers good protection for the substance		5
c. Chemically resistant gloves (*i.e.,* as *b* above) with "basic" employee training		10
d. Chemically resistant gloves in combination with specific activity training (*e.g.,* procedure for glove removal and disposal) for tasks where dermal exposure can be expected to occur	Industrial Uses Only	20
Source: (Marquart et al., 2017)		

2.6 Evidence Integration for Environmental Releases and Occupational Exposures

Evidence integration for the environmental release and occupational exposure assessment includes analysis, synthesis, and integration of information and data to produce estimates of environmental releases and occupational exposures. During evidence integration, EPA considered the likely location, duration, intensity, frequency, and quantity of releases and exposures while also considering factors that increase or decrease the strength of evidence when analyzing and integrating the data. Key factors that EPA considered when integrating evidence include the following:

1. **Data Quality:** EPA only integrated data or information rated as *high*, *medium*, *or low* obtained during the data evaluation phase of systematic review. EPA did not use data and information rated as *uninformative* in exposure evidence integration. In general, EPA gave preference to higher rankings over lower rankings; however, EPA may use lower ranked data over higher ranked data after carefully examining and comparing specific aspects of the data. For example, EPA may use a lower ranked data set that precisely matches the OES of interest over a higher ranked study that does not match the OES of interest as closely.

2. **Data Hierarchy:** EPA used both measured and modeled data to obtain accurate and representative estimates (*e.g.,* central tendency, high-end) of the environmental releases and occupational exposures resulting directly from a specific source, medium, or product. If available, measured release and exposure data are given preference over modeled data, with the highest preference given to data that are both chemical-specific and directly representative of the OES/exposure source.

EPA considered both data quality and data hierarchy when determining evidence integration strategies. For example, the Agency may use high quality modeled data that is directly applicable to a given OES over low quality measurement data that is not specific to the OES. The final integration of the environmental release and occupational exposure evidence combined decisions regarding the strength of the available information, including information on plausibility and coherence across each evidence stream. The quality of the data sources used in the release and exposure assessments for each OES are discussed in Section 4.

EPA evaluated environmental releases based on reported release data and evaluated occupational exposures based on monitoring data and worker activity information from standard engineering sources and systematic review. The Agency estimated OES-specific assessment approaches where supporting data existed and documented uncertainties where supporting data were only applicable for broader assessment approaches.

2.7 Estimating Number of Workers and Occupational Non-users

This section provides a summary of the estimates for the total exposed workers and ONUs for each OES. To prepare these estimates, EPA first identified relevant North American Industrial Classification (NAICS) codes and Standard Occupational Classification (SOC) codes from the Bureau of Labor Statistics (BLS) (2023). The estimation process for the total number of workers and ONUs is described in Section 2.7.1 below. EPA also estimated the total number facilities associated with the relevant NAICS codes based on data from the U.S. Census Bureau (2015). To estimate the average number of potentially exposed workers and ONUs per site, the total number of workers and ONUs were divided by the total number of facilities. The following sections provide additional details on the approach and methodology for estimating the number of facilities using DBP and the number of potentially exposed workers and ONUs.

2.7.1 Number of Workers and Occupational Non-users Estimation Methodology

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

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

Table 2-3 below contains the relevant NAICS codes and the calculated average number of workers and ONUs identified per site for each OES.

Table 2-3. NAICS Code Crosswalk and Number of Workers and ONUs for Each OES

Occupational Exposure Scenario (OES)	Relevant NAICS Codes	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
Manufacturing	325199 – All Other Basic Organic Chemical Manufacturing	39	18
Import and repackaging	325199 – All Other Basic Organic Chemical Manufacturing 424690 – Other Chemical and Allied Products Merchant Wholesalers	20	9
Incorporation into formulations, mixtures, or reaction product	325110 – Petrochemical Manufacturing 325199 – All Other Basic Organic Chemical Manufacturing 325510 – Paint and Coating Manufacturing 325520 – Adhesive Manufacturing 325920 – Explosives Manufacturing	34	15
PVC plastics compounding	325211 – Plastics Material and Resin Manufacturing	27	12
PVC plastics converting	326100 – Plastics Product Manufacturing	18	5
Non-PVC material manufacturing	325212 – Synthetic Rubber Manufacturing 326200 – Rubber Product Manufacturing 424690 – Other Chemical and Allied Products Merchant Wholesalers	23	6
Recycling	562212 – Solid Waste Landfill 562213 – Solid Waste Combustors and Incinerators 562219 – Other Nonhazardous Waste Treatment and Disposal	13	7
Distribution in commerce	Exposures not assessed	N/A	N/A
Industrial process solvent use	325199 – All Other Basic Organic Chemical Manufacturing	39	18
Application of adhesives and sealants	322220 – Paper Bag and Coated and Treated Paper Manufacturing 334100 – Computer and Peripheral Equipment Manufacturing 334200 – Communications Equipment Manufacturing 334300 – Audio and Video Equipment Manufacturing 334400 – Semiconductor and Other Electronic Component Manufacturing 334500 – Navigational, Measuring, Electromedical, and Control Instruments 334600 – Manufacturing and Reproducing Magnetic and Optical Media 335100 – Electric Lighting Equipment Manufacturing 335200 – Household Appliance Manufacturing 335300 – Electrical Equipment Manufacturing 335900 – Other Electrical Equipment and Component Manufacturing 336100 – Motor Vehicle Manufacturing 336200 – Motor Vehicle Body and Trailer Manufacturing 336300 – Motor Vehicle Parts Manufacturing 336400 – Aerospace Product and Parts Manufacturing 336500 – Railroad Rolling Stock Manufacturing 336600 – Ship and Boat Building 336900 – Other Transportation Equipment Manufacturing	56	18

Occupational Exposure Scenario (OES)	Relevant NAICS Codes	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
Application of paints and coatings	332431 – Metal Can Manufacturing 335931 – Current-Carrying Wiring Device Manufacturing 337124 – Metal Household Furniture Manufacturing 337214 – Office Furniture (except wood) Manufacturing 337127 – Institutional Furniture Manufacturing 337215 – Showcase, Partition, Shelving, and Locker Manufacturing 337122 – Nonupholstered Wood Household Furniture Manufacturing 337211 – Wood Office Furniture Manufacturing 337110 – Wood Kitchen Cabinet and Countertop Manufacturing 811120 – Automotive Body, Paint, Interior, and Glass Repair	12	6
Fabrication or use of final product or articles	236100 – Residential Building Construction 236200 – Nonresidential Building Construction 237100 – Utility System Construction 237200 – Land Subdivision 237300 – Highway, Street, and Bridge Construction 237900 – Other Heavy and Civil Engineering Construction 337100 – Household and Institutional Furniture Manufacturing 337200 – Office Furniture (including Fixtures) Manufacturing	9	3
Use of penetrants and inspection fluids	332100 – Forging and Stamping 332200 – Cutlery and Handtool Manufacturing 332300 – Architectural and Structural Metals Manufacturing 332400 – Boiler, Tank, and Shipping Container Manufacturing 332500 – Hardware Manufacturing 332600 – Spring and Wire Product Manufacturing 332700 – Machine Shops; Turned Product; and Screw, Nut, and Bolt 332800 – Coating, Engraving, and Heat-Treating Metals 332900 – Other Fabricated Metal Product Manufacturing 333100 – Agriculture, Construction, and Mining Machinery Manufacturing 333200 – Industrial Machinery Manufacturing 333300 – Commercial and Service Industry Machinery Manufacturing 333400 – HVAC and Commercial Refrigeration Equipment 333900 – Other General Purpose Machinery Manufacturing	13	6
Use of laboratory chemicals	541380 – Testing Laboratories 621511 – Medical Laboratories	1	9
Use of lubricants and functional fluids	336100 – Motor Vehicle Manufacturing 336200 – Motor Vehicle Body and Trailer Manufacturing 336300 – Motor Vehicle Parts Manufacturing 336400 – Aerospace Product and Parts Manufacturing 336500 – Railroad Rolling Stock Manufacturing 336600 – Ship and Boat Building 336900 – Other Transportation Equipment Manufacturing 811100 – Automotive Repair and Maintenance	88	22
Waste handling,	562212 – Solid Waste Landfill	13	7

Occupational Exposure Scenario (OES)	Relevant NAICS Codes	Exposed Workers per Site[a]	Exposed ONUs per Site[a]
treatment, and disposal	562213 – Solid Waste Combustors and Incinerators 562219 – Other Nonhazardous Waste Treatment and Disposal		
[a] For cases where multiple NAICS codes were identified for an OES, an average was calculated for the number of workers and ONUs; this average was then applied to the OES.			

2.7.2 Summary of Number of Workers and ONUs

Table 2-4 summarizes the number of facilities and total number of exposed workers for all OESs. For scenarios in which the results are expressed as a range, the lowend of the range is based on the 50th percentile estimate of the number of sites and the upper end of the range is based on the 95th percentile estimate of the number of sites. For some OESs, the estimated number of facilities is based on the number of reporting sites to the 2020 CDR (U.S. EPA, 2020a), NEI (U.S. EPA, 2023a), DMR (U.S. EPA, 2024a), and TRI databases (U.S. EPA, 2024e).

Table 2-4. Summary of Total Number of Workers and ONUs Potentially Exposed to DBP for Each OES

Occupational Exposure Scenario (OES)	Total Exposed Workers	Total Exposed ONUs	Number of Facilities	Notes
Manufacturing	195	90	5	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified sites from CDR.
Import and repackaging	560	252	28	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified sites from CDR, TRI, NEI, and DMR.
Incorporation into formulations, mixtures, and reaction products	1,700	750	50	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified sites from CDR, TRI, NEI, and DMR.
PVC plastics compounding	459	204	17	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified sites from CDR, TRI, NEI, and DMR.
PVC plastics converting	180	50	10	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified sites from CDR, TRI, NEI, and DMR.
Non-PVC material manufacturing	1,196	312	52	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified sites from CDR, TRI, NEI, and DMR.

Occupational Exposure Scenario (OES)	Total Exposed Workers	Total Exposed ONUs	Number of Facilities	Notes
Application of adhesives and sealants	5,264–44,408	1,692–14,274	94–793	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimated using modeled data.
Application of paints and coatings	2,628–31,488	1,314–15,744	219–2,624	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimated using modeled data.
Industrial process solvent use	117	54	3	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified sites from CDR, TRI, NEI, and DMR.
Use of laboratory chemicals	36,873	331,857	36,873	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimated using data from BLS.
Use of lubricants and functional fluids	293,656–3,503,104	73,414–875,776	3,337–39,808	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimated using modeled data.
Use of penetrants and inspection fluids	188,994–270,010	87,228–124,620	14,538–20,770	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimated using modeled data.
Fabrication or use of final products or articles	N/A			Number of sites data was unavailable for this OES. Based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015).
Recycling	754	406	58	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified recycling sites (see Section 3.14.2)
Waste handling, treatment, and disposal	2,951	1,589	227	Number of workers and ONU estimates based on the BLS and U.S. Census Bureau data (U.S. BLS, 2023; U.S. Census Bureau, 2015). Number of facilities estimate based on identified sites from CDR, TRI, NEI, and DMR.

3 ENVIRONMENTAL RELEASE AND OCCUPATIONAL EXPOSURE ASSESSMENTS BY OES

3.1 Manufacturing

3.1.1 Process Description

At a typical manufacturing site, DBP is formed through the esterification of the carboxyl groups phthalic anhydride with n-butyl alcohol in the presence of sulfuric acid as a catalyst. Similar to other phthalate manufacturing processes, the unreacted alcohols are recovered and reused, and the DBP mixture is purified by vacuum distillation or activated charcoal (SRC, 2001; ATSDR, 1999). According to 2020 CDR data, DBP is domestically manufactured in liquid form at concentrations at least 90 percent by weight (U.S. EPA, 2020a). Sources indicate the purity of commercial DBP can be as high as 99.5 percent (Lee et al., 2018; Zhu, 2015).

Based on manufacturing operations for similar phthalates, activities may also include filtrations and quality control sampling of the DBP product. Additionally, manufacturing operations include equipment cleaning/reconditioning and product transport to other areas of the manufacturing facility or offsite shipment for downstream processing or use. No changes to chemical composition are expected to occur during transportation (ExxonMobil, 2022a). Figure 3-1 provides an illustration of the proposed manufacturing process based on identified process information (ExxonMobil, 2022b; SRC, 2001; ATSDR, 1999).

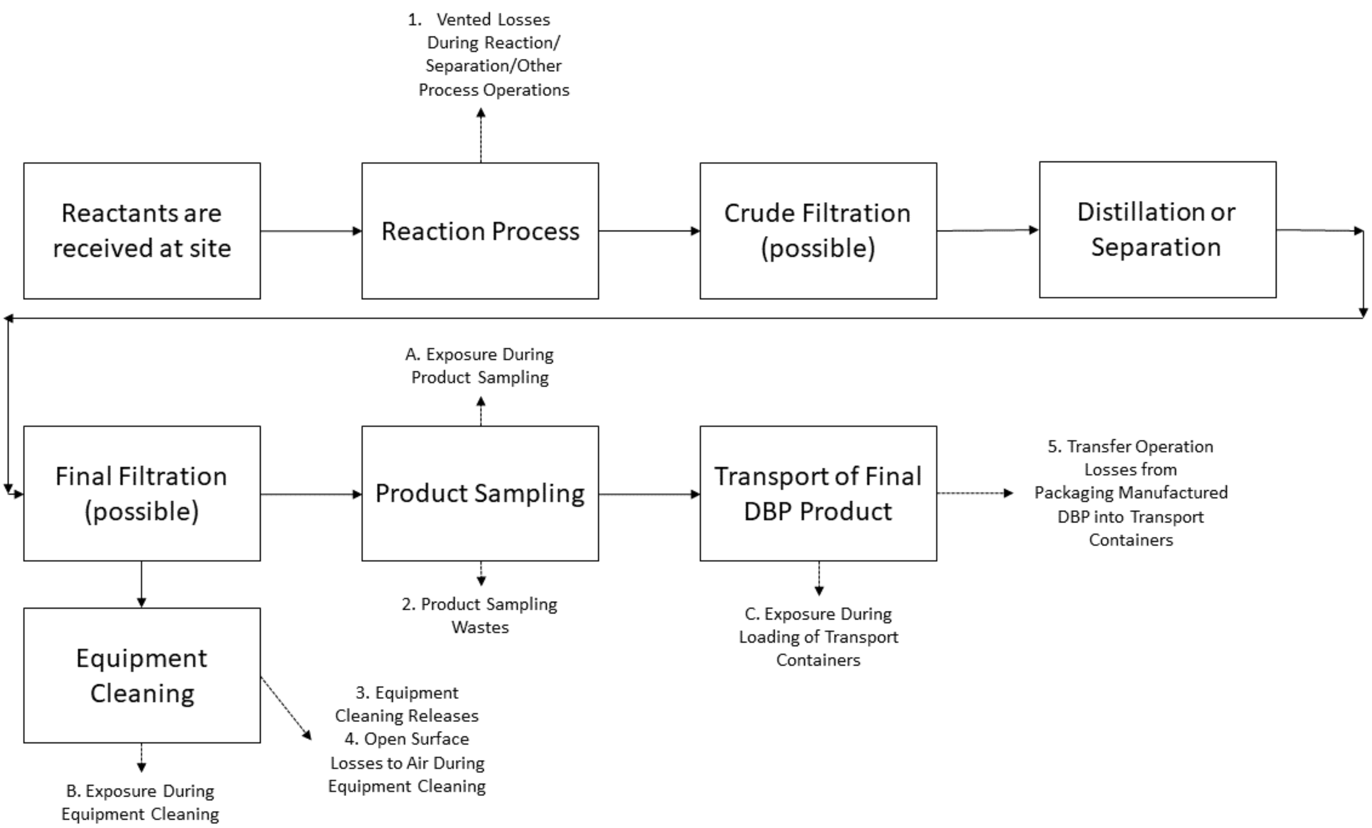


Figure 3-1. Manufacturing Flow Diagram

3.1.2 Facility Estimates

In the 2020 CDR, one site reported a production volume for the domestic manufacturing of DBP. Dystar LP in Reidsville, NC reported a production volume of 23,520 kg for the 2019 CDR reporting year (U.S. EPA, 2020a). They had previously reported between 0 and 11,353 kg DBP manufactured between 2016 to 2018. Polymer Additives, Inc. in Bridgeport, NJ reported manufacture of DBP but indicated their PV as CBI. An additional three sites reported their site activities as CBI; EPA assumed that these sites may manufacture DBP. This resulted in a total of five potential DBP manufacturing sites, two with known manufacturing activities and three sites with CBI activities.

EPA calculated the production volume for the four sites with CBI production volumes using a uniform distribution set within the national PV range for DBP. EPA calculated the bounds of the range by taking the total PV range reported in CDR and subtracting out the PVs that belonged to sites with known volumes (both manufacturing and import). Then, for each bound of the PV range, EPA divided the value by the number of sites with CBI PVs for DBP. CDR estimates a total national DBP PV of 1,000,000 to 10,000,000 lb for 2019. Based on the known PVs from importers and manufacturers, the total PV associated with the four sites with CBI PVs is 109,546 to 5,252,403 lb/year. Based on this (and after converting lb to kg), EPA set a uniform distribution for the PV for the four sites with CBI PVs with lower-bound of 49,689 kg/year, and an upper-bound of 2,382,450 kg/year. EPA used the range of production volumes as an input to the Monte Carlo modeling described in Appendix D to estimate releases. The production volume range is not used to calculate occupational exposures for DBP. Table 3-1 shows the reported PVs in CDR.

Table 3-1. Reported Manufacturing and Import Production Volumes in the 2020 CDR

Site Name	Location	Activity	Production Volume (lb)	Production Volume (kg)
Dystar LP	Reidsville, NC	Manufacture	5.2E04	2.4E04
Covalent Chemical	Raleigh, NC	Import	8.8E04	4.0E04
MAK Chemicals	Clifton, NJ	Import	1.1E05	4.8E04
GJ Chemical Co Inc	Newark, NJ	Import	1.4E05	6.3E04
Industrial Chemicals Inc	Vestavia Hills, AL	Import	4.2E05	1.9E05

EPA did not identify information from systematic review for general site throughputs; site throughput information was estimated by dividing the site PV by the number of operating days. Based on the DBP national aggregate PV reported in the 2020 CDR (1,000,000 to <10,000,000 lb), EPA assumed the number of operating days was 300 days/year with 6 day/week operations and two full weeks of downtime each operating year. CDR reporters indicated that DBP is manufactured primarily in liquid form at a concentration of 90 to 100 percent (U.S. EPA, 2020a). EPA assumed that DBP may be packaged in drums or totes with a lower-bound and mode of 20 gallons and upper-bound of 1,000 gallons based on the *ChemSTEER User Guide for the EPA/OAQPS AP-42 Loading Model* (also called "ChemSTEER User Guide" or ChemSTEER Manual") (U.S. EPA, 2015). The size of the container is an input to the Monte Carlo simulation to estimate releases, but the range is not used to calculate occupational exposures for DBP.

3.1.3 Release Assessment

3.1.3.1 Environmental Release Points

Five known sites manufacturing DBP were identified in 2020 CDR data. EPA assigned a model to quantify potential release from each release point. EPA expects stack air releases from vented losses during process operations. EPA expects water, incineration, or landfill releases from product sampling and equipment cleaning. EPA expects fugitive air releases from equipment cleaning and transfer operations from packaging manufactured DBP.

3.1.3.2 Environmental Release Assessment Results

Table 3-2 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES. See Appendix D.2.2 for additional details on model equations, and different parameters used for Monte Carlo modeling. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively. The *Draft Manufacturing OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP)* also contains additional information about model equations and parameters and calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-2. Summary of Modeled Environmental Releases for Manufacture of DBP

Modeled Scenario	Environmental Media	Annual Release (kg/site-year)		Number of Release Days		Daily Release[b] (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
23,520 kg/year production volume (Dystar LP)	Stack Air	0.24	0.24	300		7.8E−04	7.8E−04
	Fugitive Air	9.9E−04	1.7E−03			3.3E−06	5.5E−06
	Water, Incineration, or Landfill[a]	558	585			1.9	2.0
49,689-2,382,450 kg/year production volume (Other 4 sites)	Stack Air	3.0	5.7	300		1.0E−02	1.9E−02
	Fugitive Air	7.8E−04	1.6E−03			2.6E−06	5.4E−06
	Water, Incineration, or Landfill[a]	6,942	1.3E04			23	43

[a] When multiple environmental media are addressed together, releases may go all to one media or be split between media depending on site-specific practices. Not enough data were provided to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.1.4 Occupational Exposure Assessment

3.1.4.1 Workers Activities

During manufacturing, worker exposures to DBP may occur via inhalation of vapor or dermal contact with liquid during product sampling, equipment cleaning, container cleaning, and packaging and loading of DBP into transport containers for shipment. EPA did not identify information on engineering controls or worker PPE used at DBP manufacturing facilities. EPA also did not seek specific information on safety protocols, engineering controls or standard operating procedures (SOPs) from facilities manufacturing DBP.

ONUs include employees (*e.g.*, supervisors, managers) who work at the manufacturing facility but do not directly handle DBP. Generally, EPA expects ONUs to have lower inhalation and dermal exposures than workers who handle the chemicals directly. Nevertheless, potential exposures to ONUs through inhalation of vapors are assessed under the Manufacturing OES.

3.1.4.2 Occupational Inhalation Exposure Results

EPA identified inhalation monitoring data from three risk evaluations, however, each study only presents a single aggregate or final data point during manufacturing of DBP. In the first source, the Syracuse Research Corporation indicates that "following a review of six studies, the American Chemistry Council has estimated exposure to di-n-butyl phthalate in the workplace based upon an assumed level of 1 mg/m^3 in the air during the production of phthalates." (SRC, 2001). The second source, a risk evaluation of 1,3,4,6,7,8-Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-g-2-benzopyran (HHCB) conducted by European Commission, Joint Research Centre (ECJRC) presented an 8-hour TWA aggregate exposure concentration for DBP of 0.003 ppm (n = 114) for a DBP manufacturing site (ECB, 2008). The third source, a risk evaluation of DBP also conducted by the ECJRC provides seven separate datasets from two unnamed manufacturers. Of these datasets six did not include a sampling method and were not used. Only one had sufficiently detailed metadata (*e.g.*, exposure duration, sample type) to include in this assessment; an 8-hour TWA worker exposure concentration to DBP of 0.5 mg/m^3 from DBP production (ECB, 2004). With three aggregate or final concentration value from three sources, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the manufacturing process, the Agency used the maximum available value (1 mg/m^3). EPA assessed the midpoint of the three available values as the central tendency (0.5 mg/m^3). All three sources of monitoring data received a rating of medium from EPA's systematic review process.

Table 3-3 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during manufacture. In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. The central tendency and high-end exposures use 250 days per year as the exposure frequency, which is the expected maximum for working days. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP in the form of vapors. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-3. Summary of Estimated Worker Inhalation Exposures for Manufacture of DBP

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.50	1.0
	Acute dose (AD) (mg/kg-day)	6.3E−02	0.13
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−02	9.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−02	8.6E−02
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.50	1.0
	Acute Dose (AD) (mg/kg-day)	6.9E−02	0.14
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	5.1E−02	0.10
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.7E−02	9.5E−02
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.50	0.50
	Acute Dose (AD) (mg/kg-day)	6.3E−02	6.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−02	4.6E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−02	4.3E−02

[a] EPA identified inhalation monitoring data from three sources to estimate exposures for this OES (ECB, 2008, 2004; SRC, 2001). All three sources of monitoring data received a rating of medium from EPA's systematic review process. With the three discrete data points, the Agency could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the manufacturing process, EPA used the maximum available value (1 mg/m^3). The Agency assessed the midpoint of the three available values as the central tendency (0.5 mg/m^3).

3.1.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-4 are explained in Appendix A. ONU dermal exposures are not assessed for this OES as there are no activities expected to expose ONUs to DBP in liquid form. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper PPE or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-4 summarizes the APDR, AD, IADD, and ADD for average adult workers and female workers of reproductive age. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-4. Summary of Estimated Worker Dermal Exposures for the Manufacturing of DBP

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	100	201
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.92	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.86	1.7
Female of Reproductive Age	Dose Rate (APDR, mg/day)	84	167
	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.85	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.79	1.6

Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).

3.1.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-5. Summary of Estimated Worker Aggregate Exposures for Manufacture of DBP

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.3	2.6
	Intermediate (IADD, mg/kg-day)	0.97	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.90	1.8
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.2	2.4
	Intermediate (IADD, mg/kg-day)	0.90	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.84	1.7
ONU	Acute (AD, mg/kg-day)	6.3E−02	6.3E−02
	Intermediate (IADD, mg/kg-day)	4.6E−02	4.6E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	4.3E−02

Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

3.2 Import and Repackaging

3.2.1 Process Description

DBP may be imported into the United States in bulk via water, air, land, and intermodal shipments (Tomer and Kane, 2015). These shipments take the form of oceangoing chemical tankers, railcars, tank trucks, and intermodal tank containers. Chemicals may be repackaged by wholesalers for resale, for example, repackaging bulk packaging into drums or bottles. The type and size of container will vary depending on customer requirement.

Based on the Chemical Repackaging Generic Scenario, import and repackaging sites unload the import containers and transfer DBP into smaller containers (drums or bottles) for downstream processing, use within the facility, or offsite use. Operations may include quality control sampling of DBP product and equipment cleaning. Some import facilities may only serve as storage and distribution locations, and repackaging/sampling may not occur at all import facilities. No changes to chemical composition occur during repackaging (U.S. EPA, 2022a).

According to the 2020 CDR, DBP is shipped in liquid form. One facility reported DBP was imported at a concentration of 1 to 30 percent, one facility reported DBP concentrations of 60 to 90 percent and nine facilities reported DBP concentrations were at least 90 percent (U.S. EPA, 2020a). Sources indicate the purity of neat commercial DBP is 99.5 percent (Lee et al., 2018; Zhu, 2015). Figure 3-2 provides an illustration of the import and repackaging process.

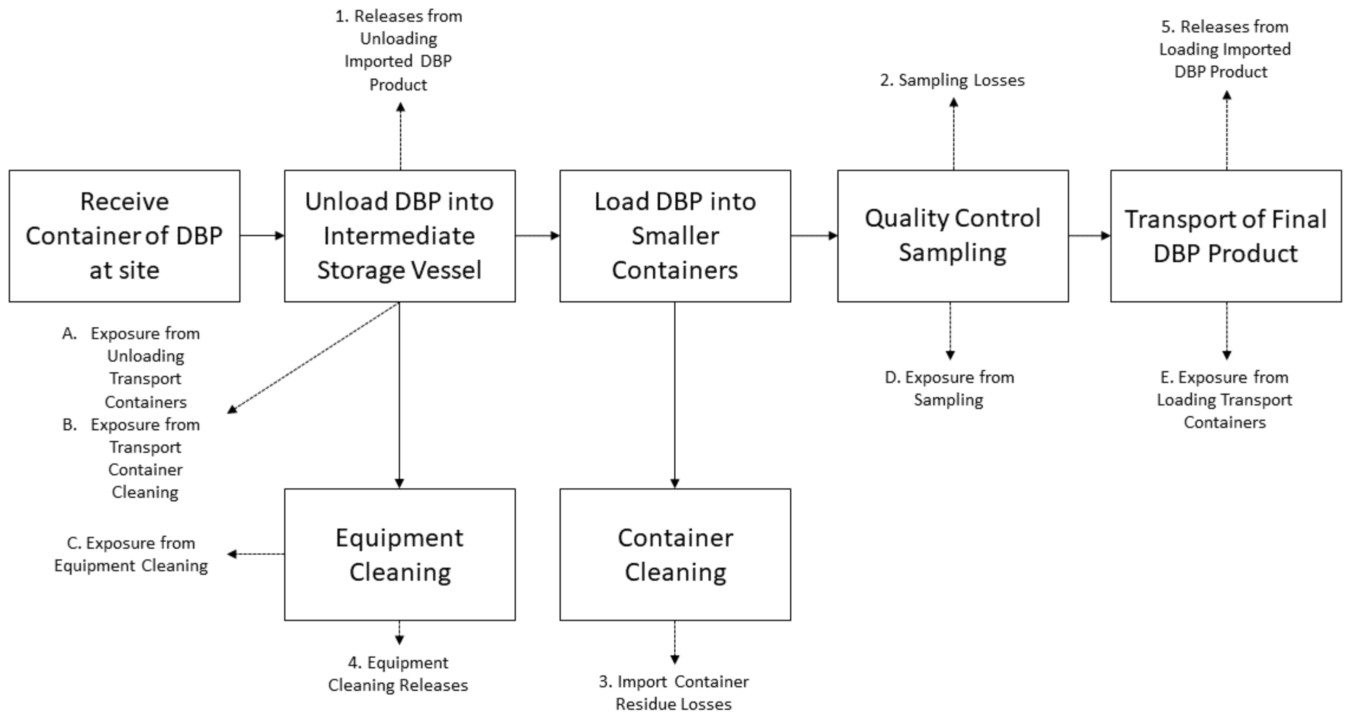


Figure 3-2. Import and Repackaging Flow Diagram (U.S. EPA, 2022a)

3.2.2 Facility Estimates

In the 2020 CDR, 10 sites reported import of DBP and are listed in the table below. Two sites reported both manufacturing and import activities – Covalent Chemical and BAE Systems; one site withheld their site activity – Shrieve Chemical Company, LLC, and two sites claimed CBI for their site name, location, and activity. In the NEI (U.S. EPA, 2023a), DMR (U.S. EPA, 2024a), and TRI (U.S. EPA, 2024e) data that EPA analyzed, EPA identified that an additional 15 sites may repackage DBP based on site names and their reported NAICS and SIC codes. EPA identified two reports from NEI air release data indicating 365 operating days. TRI/DMR did not report operating days; therefore, EPA assumed 260 days/year of operation based on the Repackaging GS Revised Draft, as discussed in Section 2.3.2 (U.S. EPA, 2022a). Table 3-6 presents the production volume of DBP repackaging sites.

Table 3-6. Production Volume of DBP Repackaging Sites, 2020 CDR

DBP Repackaging Site, Site Location	2019 Reported Import Production Volume (kg/year)
Lanxess Corporation, Pittsburgh, PA	0
Univar Solutions USA Inc., Redmond, WA	0
MAK Chemicals, Clifton, NJ	105,884
GJ Chemical Co Inc., Newark, NJ	139,618
Industrial Chemicals Inc., Vestavia Hills, AL	422,757
Allchem Industries Industrial Chemicals Group, Inc., Gainesville, FL	0
Sika Corp, Lyndhurst, NJ	0
The Sherwin-Williams Company, Cleveland, OH	CBI
Huntsman Corporation – The Woodlands Corporate Site, Montgomery, TX	CBI
Greenchem, West Palm Beach, FL	CBI
Covalent Chemical, Raleigh, NC	88,184
BAE Systems, Radford, VA	0
Shrieve Chemical Company LLC, Spring, TX	CBI
CBI	CBI
CBI	CBI

EPA evaluated the production volumes for sites that reported this information as CBI by subtracting known production volumes for other manufacturing and import sites from the total DBP production volume reported to the 2020 CDR. EPA considered production volumes for both import and manufacturing sites because the annual DBP production volume in the CDR includes both domestic manufacture and repackaging. The 2020 CDR reported a range of national production volume for DBP; therefore, the Agency provided the import and repackaging production volume as a range. EPA split the remaining production volume range evenly across all sites that reported this information as CBI. The calculated production volume range for the sites with CBI or withheld production volumes resulted in 12,423 to 595,613 kg/site-year.

3.2.3 Release Assessment

3.2.3.1 Environmental Release Points

Based on TRI, DMR and NEI data, repackaging releases may go to fugitive air, stack air, surface water, POTWs, and landfills (U.S. EPA, 2024a, e, 2023a). Additional releases may occur from transfers of wastes to off-site treatment facilities (assessed in the Waste handling, treatment, and disposal OES). Fugitive air releases may occur during sampling, equipment cleaning, and container loading. Stack air releases may occur from vented losses during process operations. Releases to surface water, POTWs, or landfills may occur from equipment cleaning wastes, process wastes, and sampling wastes. Surface water releases may occur from container cleaning. Additional fugitive air releases may occur during leakage of pipes, flanges, and other equipment used for transport.

3.2.3.2 Environmental Release Assessment Results

Table 3-7 presents fugitive and stack air releases per year and per day for DBP Repackaging based on the 2017 to 2022 TRI database years along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. Table 3-8 presents fugitive and stack air releases per year and per day based on the 2020 NEI database along with the number of release days per year. Table 3-9 presents land releases per year based on the 2017 to 2022 TRI database along with the number of release days per year. Table 3-10 presents water releases per year and per day based on the 2017 to 2022 TRI database along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. Some sites qualified to report their releases under TRI form A because the amount of the chemical manufactured, processed, or used were below 1,000,000 lb and the total reportable release did not exceed 500 lb (227 kg). The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)*, *Draft Summary of Results for Identified Environmental Releases to Land for Dibutyl Phthalate (DBP)*, and *Draft Summary of Results for Identified Environmental Releases to Water for Dibutyl Phthalate (DBP)* contain additional information about these identified releases and their original sources; refer to Appendix F for a reference to these supplemental documents.

1861 **Table 3-7. Summary of Air Releases from TRI for Repackaging**

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Median Annual Fugitive Air Release (kg/year)	Median Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)	Median Daily Fugitive Air Release (kg/day)	Median Daily Stack Air Release (kg/day)
Superior Industrial Solutions Inc.	227	227	0	0	260	0.87	0.87	3.4E−03	0
Doremus Terminal LLC	1.4	0	0.68	0	260	5.2E−03	0	0	0
Univar Solutions-Doraville	113	4.5E−05	2.5	0	260	0.44	1.7E−07	6.7E−10	0
Harwick Standard Distribution Corp	0.45	0	0.45	0	260	1.7E−03	0	0	0
Greenchem Industries LLC	0	0	0	0	260	0	0	0	0
Superior Industrial Solutions Inc.	227	227	227	227	260	0.87	0.87	3.4E−03	0.87
Wego Chemical Group	0	0	0	0	260	0	0	0	0
The Dow Chemical Co – Louisiana Operations	0	0	0	0	260	0	0	0	0
Barton Solvents Inc Council Bluffs	0	0	0	0	260	0	0	0	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Median Annual Fugitive Air Release (kg/year)	Median Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)	Median Daily Fugitive Air Release (kg/day)	Median Daily Stack Air Release (kg/day)
SolvChem Inc. – Pearland Facility	0	0	0	0	260	0	0	0	0

Table 3-8. Summary of Air Releases from NEI (2020) and NEI (2017) for Repackaging

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Tanker Terminal Bayport (2020)	35	0	364	9.5E−02	0
Univar Solutions USA, Inc. (1677130036) (2020)	8.2	0	365	2.2E−02	0
Galena Park Terminal (2017)	113	0	365	0.31	0
Conroe Plant (2017)	N/A	0	365	N/A	0

Table 3-9. Summary of Land Releases from TRI for Repackaging

Site Identity	Median Annual Release (kg/year)	Maximum Annual Release (kg/year)	Annual Release Days (days/year)
Harwick Standard Distribution Corp	56	873	260
US Navy NSWC Crane Div Installation Activity – Installation	1.2E04	3.7E04	260

Table 3-10. Summary of Water Releases from TRI/DMR for Repackaging

Site Identity	Source- Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
GreenChem Industries LLC	TRI Form A – Direct	227	0.87	227	0.87	260
GreenChem Industries LLC	TRI Form A – Transfer to POTW	227	0.87	227	0.87	260
GreenChem Industries LLC	TRI Form A – Transfer to Non-POTW	227	0.87	227	0.87	260
IMTT-BC	DMR	1.1E−02	4.0E−05	1.1E−02	4.0E−05	260
Superior Industrial Solutions Inc.	TRI Form A – Direct	227	0.87	227	0.87	260
Superior Industrial Solutions Inc.	TRI Form A – Direct	227	0.87	227	0.87	260
Univar Solutions – Doraville	TRI Form A – Direct	227	0.87	227	0.87	260
Superior Industrial Solutions Inc.	TRI Form A – Transfer to POTW	227	0.87	227	0.87	260
Superior Industrial Solutions Inc.	TRI Form A – Transfer to POTW	227	0.87	227	0.87	260
Univar Solutions-Doraville	TRI Form A – Transfer to POTW	227	0.87	227	0.87	260

Site Identity	Source- Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Superior Industrial Solutions Inc.	TRI Form A – Transfer to Non-POTW	227	0.87	227	0.87	260
Superior Industrial Solutions Inc.	TRI Form A – Transfer to Non-POTW	227	0.87	227	0.87	260
Univar Solutions – Doraville	TRI Form A – Transfer to Non-POTW	227	0.87	227	0.87	260

3.2.4 Occupational Exposure Assessment

3.2.4.1 Workers Activities

During import and repackaging, worker exposures to DBP occur when transferring DBP from the import vessels into smaller containers. Worker exposures also occur via inhalation of vapor or dermal contact with liquid when cleaning import vessels, loading and unloading DBP, sampling, and cleaning equipment. EPA did not find any information on the extent to which engineering controls and worker PPE are used at facilities that repackage DBP from import vessels into smaller containers.

ONUs include employees (*e.g.*, supervisors, managers) that work at the import site where repackaging occurs but do not directly handle DBP. Therefore, EPA expects ONUs to have lower inhalation exposures and dermal exposures than workers. Nevertheless, potential exposures to ONUs through inhalation of vapors is assessed under the Import and Repackaging OES.

3.2.4.2 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for import and repackaging from systematic review of literature sources. DBP is imported as a liquid, per CDR, and EPA assessed worker inhalation exposures to DBP vapor during the unloading and loading processes. EPA used DBP manufacturing monitoring data to estimate inhalation exposures. EPA identified inhalation monitoring data from three risk evaluations, however, each study only presents a single aggregate or final data point during manufacturing of DBP. In the first source, the Syracuse Research Corporation indicates that "following a review of six studies, the American Chemistry Council has estimated exposure to di-n-butyl phthalate in the workplace based upon an assumed level of 1 mg/m^3 in the air during the production of phthalates." (SRC, 2001). The second source, a risk evaluation of 1,3,4,6,7,8-Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-g-2-benzopyran (HHCB) conducted by European Commission, Joint Research Centre (ECJRC) presented an 8-hour TWA aggregate exposure concentration for DBP of 0.003 ppm (n = 114) for a DBP manufacturing site (ECB, 2008). The third source, a risk evaluation of DBP also conducted by the ECJRC provides seven separate datasets from two unnamed manufacturers. Of these datasets, six did not include a sampling method and were not used. Only one had sufficiently detailed metadata (*e.g.*, exposure duration, sample type) to include in this assessment; an 8-hour TWA worker exposure concentration to DBP of 0.5 mg/m^3 from DBP production (ECB, 2004). With three aggregate or final concentration value from three sources, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the manufacturing process, the Agency used the maximum available value (1 mg/m^3). EPA assessed the midpoint of the three available values as the central tendency (0.5 mg/m^3). All three sources of monitoring data received a rating of medium from EPA's systematic review process. In absence of data specific to ONU exposure, the Agency assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. EPA assessed the exposure frequency as 250 days/year for both high-end and central tendency exposures based on the expected operating days for the OES and accounting for off days for workers.

Table 3-11 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during import and repackaging. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP in the form of vapor. Because DBP is imported as a liquid as opposed to solid, inhalation exposures to vapor is more likely than dust. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-11. Summary of Estimated Worker Inhalation Exposures for Import and Repackaging of DBP

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.50	1.0
	Acute Dose (AD) (mg/kg-day)	6.3E−02	0.13
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−02	9.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−02	8.6E−02
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.50	1.0
	Acute Dose (AD) (mg/kg-day)	6.9E−02	0.14
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	5.1E−02	0.10
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.7E−02	9.5E−02
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.50	0.50
	Acute Dose (AD) (mg/kg-day)	6.3E−02	6.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−02	4.6E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−02	4.3E−02

[a] EPA identified surrogate inhalation monitoring data from three sources to estimate exposures for this OES (ECB, 2008, 2004; SRC, 2001). All three sources of monitoring data received a rating of medium from EPA's systematic review process. With the three discrete data points, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the manufacturing process, the Agency used the maximum available value (1 mg/m^3). EPA assessed the midpoint of the three available values as the central tendency (0.5 mg/m^3).

3.2.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-12 are explained in Appendix A. ONU dermal exposures are not assessed for this OES as there are no activities expected to expose ONUs to DBP in liquid form. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-12 summarizes the APDR, AD, IADD, and ADD for average adult workers and female workers. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to 4.2Appendix F for a reference to this supplemental document.

Table 3-12. Summary of Estimated Worker Dermal Exposures for Import and Repackaging of DBP

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	100	201
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.92	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.86	1.7
Female of Reproductive Age	Dose Rate (APDR, mg/day)	84	167
	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.85	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.79	1.6

Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).

3.2.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-13. Summary of Estimated Worker Aggregate Exposures for Import and Repackaging of DBP

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.3	2.6
	Intermediate (IADD, mg/kg-day)	0.97	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.90	1.8
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.2	2.5
	Intermediate (IADD, mg/kg-day)	0.90	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.84	1.7
ONU	Acute (AD, mg/kg-day)	6.3E−02	6.3E−02
	Intermediate (IADD, mg/kg-day)	4.6E−02	4.6E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	4.3E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.3 Incorporation into Formulations, Mixtures, and Reaction Products

3.3.1 Process Description

"Incorporation into formulations, mixtures, and reaction products" refers to the process of mixing or blending of several raw materials to obtain a single product or preparation. Exact process operations involved in the incorporation of DBP into a chemical formulation, mixture, or reaction product are dependent on the specific manufacturing process or processes involved. EPA expects that each individual formulation process is small; therefore, EPA assessed releases and exposures for the incorporation of DBP into a chemical formulation, mixture, or reaction product as a group rather than individually. Companies reported to the 2020 CDR that DBP is used as a plasticizer in the manufacture of paints and coatings, soap, cleaning compounds, and toilet preparation manufacturing (NLM, 2024; U.S. EPA, 2020a). DBP is also used in the formulation ink, toner, and colorant products, as a functional fluid in printing activities, and as a solvent in other chemical manufacturing (U.S. EPA, 2020a). The concentration of DBP in the formulation varies widely depending on the type of formulation (*e.g.*, paint, adhesive, dye, ink).

DBP-specific formulation processes were not identified; however, the Agency identified several ESDs published by the OECD and Generic Scenarios published by EPA that provide general process descriptions for these types of products. The manufacture of coatings involves four steps. The formulation of coatings and inks typically involves dispersion, milling, finishing and filling into final packages (U.S. EPA, 2010). Modern processes can combine the final steps by creating intermediate formulations during the first two steps. The intermediates are then dispensed directly into the shipping containers for the final blending in order to produce the end-product (U.S. EPA, 2010).

Waterborne coatings are produced with the same approach, using water as one of the liquid ingredients (U.S. EPA, 2010). Adhesive formulation involves mixing volatile and non-volatile chemical components together in sealed, unsealed, or heated processes (OECD, 2009a). Sealed processes are most common for adhesive formulation because many adhesives are designed to set or react when exposed to ambient conditions (OECD, 2009a). The manufacturing process for radiation curable coating products is similar to adhesive formulation, with volatile and non-volatile chemical components being mixed in an open or sealed batch process, with the photoinitiator being added last. The high cost of radiation curable raw materials has led to the use of practices to reduce container residues, such as heating containers to reduce viscosity (OECD, 2010).

DBP has been identified in quantities ranging from 0.1 to 75 percent in adhesives, sealants, paints, and coatings. In addition, two CDR entries reported a concentration of at least 90 percent DBP in the formulation of adhesives, sealants and inks (U.S. EPA, 2020a). Figure 3-3 provides an illustration of the incorporation into formulations, mixtures, and reaction products process.

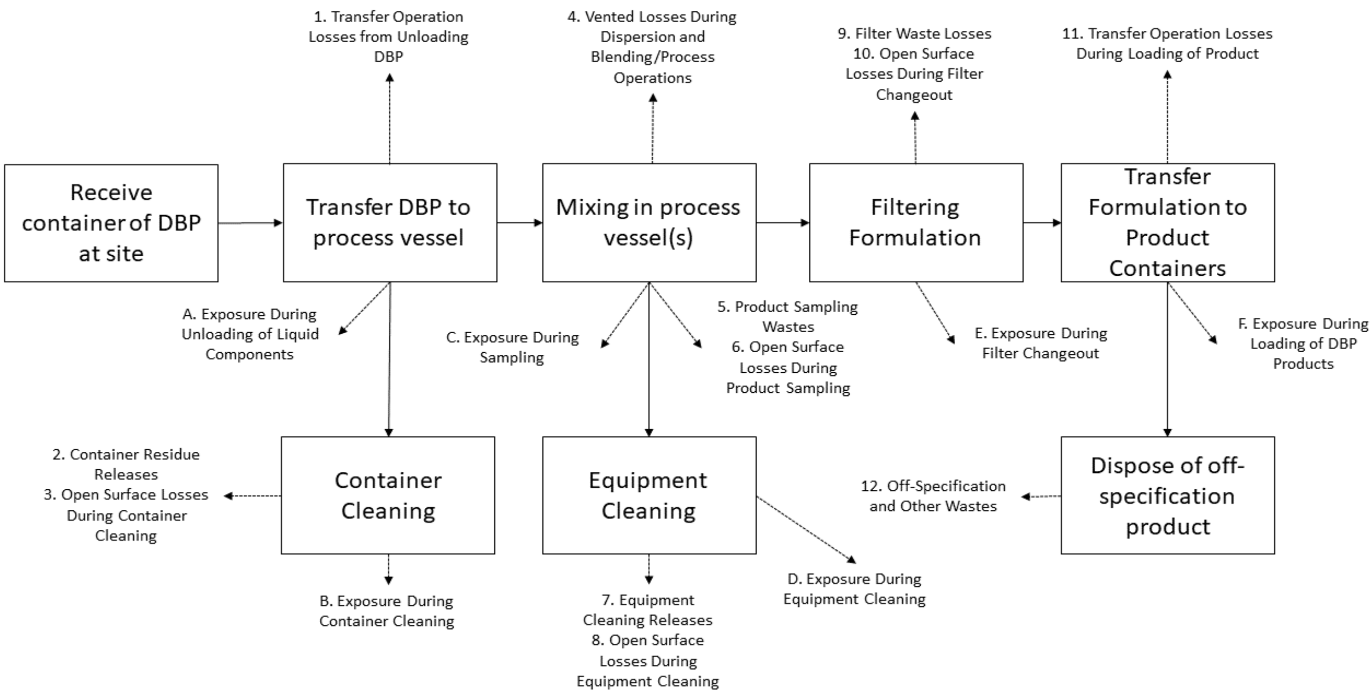


Figure 3-3. Incorporation into Formulations, Mixtures, and Reaction Products Flow Diagram (U.S. EPA, 2014a)

3.3.2 Facility Estimates

In the NEI (U.S. EPA, 2023a, 2019), DMR (U.S. EPA, 2024a), and TRI (U.S. EPA, 2024e) data that EPA analyzed, EPA identified 50 sites that may have used DBP in incorporative activities based on site names and their reported NAICS and SIC codes. Due to the lack of data on the annual PV of DBP in incorporation into formulation, mixture, or reaction products, EPA does not present annual or daily site throughputs. The ESD on Formulation of Radiation Curable Coatings, Inks and Adhesives estimates 250 operating days/year and an annual production rate of 130,000 kg formulation/site-year (OECD, 2010). EPA identified operating days ranging from 250 to 365 days with an average of 252 days through NEI air release data. TRI/DMR data did not report operating days; therefore, EPA assumed 250 days/year of operation as discussed in Section 2.3.2.

3.3.3 Release Assessment

3.3.3.1 Environmental Release Points

Based on TRI and NEI data, Incorporation into formulation, mixture, or reaction product releases may go to stack air, fugitive air, surface water, POTW, and landfill (U.S. EPA, 2024e, 2023a, 2019). Additional releases may occur from transfers of waste to off-site treatment facilities (assessed in the Waste handling, treatment, and disposal OES). Stack air releases may occur from vented losses during mixing, vented during transfer, and vented losses during process operations. POTW, incineration, or landfill releases may occur from container residue, sampling wastes, equipment cleaning wastes, and off-specification wastes. Incineration or landfill releases may occur from filter waste. Additional fugitive air releases may occur during leakage from pipes, flanges, and accessories used for transport (OECD, 2010, 2009a).

3.3.3.2 Environmental Release Assessment Results

Table 3-14 summarizes the fugitive and stack air releases per year and per day for incorporation into formulation, mixture, or reaction product based on the 2017 to 2022 TRI database reporting years along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. Table 3-15 presents fugitive and stack air releases per year and per day based on the 2020 NEI database along with the number of release days per year. Table 3-16 presents fugitive and stack air releases per year and per day based on the 2017 NEI database along with the number of release days per year. Table 3-17 presents land releases per year based on reports from TRI. Table 3-18 presents water releases per year and per day based on the 2017 to 2022 TRI database along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. Some sites qualified to report their releases under TRI form A because the amount of the chemical manufactured, processed, or used were below 1,000,000 lb and the total reportable release did not exceed 500 lb (227 kg). The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)*, *Draft Summary of Results for Identified Environmental Releases to Land for Dibutyl Phthalate (DBP)*, and *Draft Summary of Results for Identified Environmental Releases to Water for Dibutyl Phthalate (DBP)* contain additional information about these identified releases and their original sources; refer to Appendix F for a reference to these supplemental documents.

Table 3-14. Summary of Air Releases from TRI for Incorporation into Formulation, Mixture, or Reaction Product

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Median Annual Fugitive Air Release (kg/year)	Median Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/year)	Maximum Daily Stack Air Release (kg/day)	Median Daily Fugitive Air Release (kg/day)	Median Daily Stack Air Release (kg/day)
Penn Color Inc.	227	227	0	0	250	0.91	0.91	0	0
St. Marks Powder Inc.	0	0	0	0	250	0	0	0	0
Century Industrial Coatings Inc.	41	787	0	0	250	0.17	3.2	0	0
Lanxess Corp-Baytown	182	0.91	109	0.91	250	0.73	3.6E−03	0.43	3.6E−03
Arkema Inc.	0	0	0	0	250	0	0	0	0
Grace-Pasadena Catalyst Site	298	224	224	0.45	250	1.2	0.89	0.89	1.8E−03
Prime Resins Inc.	0	0	0	0	250	0	0	0	0
Sika Corp-Marion Operations	0	0	0	0	250	0	0	0	0
GAF	227	227	0	0	250	0.91	0.91	0	0
Polycoat Products LLC	227	227	0	0	250	0.91	0.91	0	0
Henkel Us Operations Corp	227	227	0	0	250	0.91	0.91	0	0
Amvac Chemical Co	227	227	0	0	250	0.91	0.91	0	0
Lanco Manufacturing Corp	6.1	5.4E−04	4.9	3.8E−04	250	2.4E−02	2.1E−06	1.9E−02	1.5E−06
The Sierra Co LLC	199	0	199	0	250	0.79	0	0.79	0
Essential Industries Inc	227	227	227	227	250	0.91	0.91	0.91	0.91
Buckeye International Inc.	227	227	113	113	250	0.91	0.91	0.45	0.45
National Chemical Laboratories Inc	0	0	0	0	250	0	0	0	0
Evonik Corp	0	0	0	0	250	0	0	0	0

Table 3-15. Summary of Air Releases from NEI (2020) for Incorporation into Formulation, Mixture, or Reaction Product

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Owens Corning Roofing and Asphalt, LLC	N/A	0	250	N/A	0
Tamko Building Products LLC	3.6E−03	0	250	1.5E−05	0
Frazee Industries	11	N/A	250	4.5E−02	N/A
General Polymer, Inc.	0.91	N/A	250	3.6E−03	N/A
Marcus Paint Company	0	N/A	250	0	N/A
Crane Div Naval Surface Warfare Ctr NSW	100	0	250	0.40	0
Tamko Building Products LLC Rangeline Plant	N/A	0	250	N/A	0
True Value Manufacturing Co	N/A	8.7	250	N/A	3.5E−02
Covestro Industrial Park Baytown	12	N/A	365	3.2E−02	N/A
Plasti-Dip International	N/A	19	250	N/A	7.5E−02
Owens Corning – Minneapolis Plant	N/A	0	250	N/A	0
Tl Edwards Inc	2.0E−06	N/A	250	7.8E−09	N/A
Forest County Highway Dept	N/A	0	250	N/A	0
Sierra Corp	33	0	250	0.13	0
Ceramic Industrial Coatings	4.4	0	250	1.8E−02	0
Certainteed LLC	N/A	0	250	N/A	0
3M Alexandria	N/A	0	250	N/A	0
Gaf Materials Corp	N/A	0	250	N/A	0
Palmer Paving Corp	0	N/A	250	0	N/A
Akron Paint and Varnish (1677010028)	5.4	N/A	260	2.1E−02	N/A
Lanco Mfg Corp	4.9	0	250	1.9E−02	0
Tnemec Company	N/A	0	250	N/A	0
Tnemec Company Inc North Kansas City	N/A	0	250	N/A	0
Akzonobel Aerospace Coating	N/A	7.3	250	N/A	2.9E−02
Itw Phila Resins/Montgomery	0.91	0	250	3.6E−03	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Certainteed Corporation	0.20	0	250	8.1E−04	0
Glenn O Hawbaker Inc/Dubois Plt 4	N/A	0	181	N/A	0
Stark Pavement Corp – Ultra 135-85577-00-Na	N/A	0	250	N/A	0

Table 3-16. Summary of Air Releases from NEI (2017) for Incorporation into Formulation, Mixture, or Reaction Product

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/year)	Maximum Daily Stack Air Release (kg/year)
CertainTeed Corp	N/A	0	250	N/A	0
Trumbull Asphalt	N/A	0	250	N/A	0
Kop-Coat, Inc.	34	N/A	250	0.14	N/A
Bradley Laboratories	N/A	1.5	250	N/A	5.8E−03
Century Industrial Coatings Inc	5.0	0	250	2.0E−02	0

Table 3-17. Summary of Land Releases from TRI for Incorporation into Formulation, Mixture, or Reaction Product

Site Identity	Median Annual Release (kg/year)	Maximum Annual Release (kg/year)	Annual Release Days (days/year)
St. Marks Powder Inc.	510	723	250
Rubicon LLC	2,629	1.0E04	250
Century Industrial Coatings Inc.	2.7	552	250

Table 3-18. Summary of Water Releases from TRI for Incorporation into Formulation, Mixture, or Reaction Product

Site Identity	Source- Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Amvac Chemical Co	TRI Form A – Direct	227	0.91	227	0.91	250
Amvac Chemical Co	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
Amvac Chemical Co	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250
Arkema Inc.	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
Arkema Inc.	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250
Buckeye International Inc.	TRI Form A – Direct	227	0.91	227	0.91	250
Essential Industries Inc	TRI Form A – Direct	227	0.91	227	0.91	250
GAF	TRI Form A – Direct	227	0.91	227	0.91	250
Buckeye International Inc.	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
Essential Industries Inc	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
GAF	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
Buckeye International Inc.	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250
Essential Industries Inc	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250
GAF	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250
Grace -Pasadena Catalyst Site	TRI Form R – Transfer to POTW	1,743	7.0	3,630	15	250
Henkel Us Operations Corp	TRI Form A – Direct	227	0.91	227	0.91	250
Henkel Us Operations Corp	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
Henkel US Operations Corp	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250
National Chemical Laboratories Inc	TRI Form R – Transfer to POTW	2.3	2.3	9.1E−03	9.1E−03	250
Penn Color Inc.	TRI Form A – Direct	227	0.91	227	0.91	250
Polycoat Products LLC	TRI Form A – Direct	227	0.91	227	0.91	250
Sika Corp-Marion Operations	TRI Form A – Direct	227	0.91	227	0.91	250

Site Identity	Source- Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Penn Color Inc.	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
Polycoat Products LLC	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
Sika Corp-Marion Operations	TRI Form A – Transfer to POTW	227	0.91	227	0.91	250
Penn Color Inc.	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250
Polycoat Products LLC	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250
Sika Corp-Marion Operations	TRI Form A – Transfer to Non-POTW	227	0.91	227	0.91	250

3.3.4 Occupational Exposure Assessment

3.3.4.1 Worker Activities

During the formulation of products containing DBP, workers are potentially exposed to DBP via inhalation or dermal contact with vapors and liquids when unloading DBP, packaging final products, cleaning transport containers, product sampling, equipment cleaning, and during filter media change out (U.S. EPA, 2014a). EPA did not identify information on engineering controls or workers PPE used at other formulation sites.

For this OES, ONUs may include supervisors, managers, and other employees that work in the formulation area but do not directly contact DBP that is received or processed onsite or handle the formulated product.

3.3.4.2 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for incorporation into formulations, mixtures, and reaction products from systematic review of literature sources. DBP is imported and manufactured as a liquid, per CDR, and EPA assessed worker inhalation exposures to DBP vapor during the unloading and loading processes. EPA used DBP manufacturing monitoring data to estimate inhalation exposures. EPA identified inhalation monitoring data from three risk evaluations, however, each study only presents a single aggregate or final data point during manufacturing of DBP. In the first source, the Syracuse Research Corporation indicates that "following a review of six studies, the American Chemistry Council has estimated exposure to di-n-butyl phthalate in the workplace based upon an assumed level of 1 mg/m^3 in the air during the production of phthalates." (SRC, 2001). The second source, a risk evaluation of 1,3,4,6,7,8-Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-g-2-benzopyran (HHCB) conducted by European Commission, Joint Research Centre (ECJRC) presented an 8-hour TWA aggregate exposure concentration for DBP of 0.003 ppm (N=114) for a DBP manufacturing site (ECB, 2008). The third source, a risk evaluation of DBP also conducted by the ECJRC provides seven separate datasets from two unnamed manufacturers. Of these datasets six did not include a sampling method and were not used. Only one had sufficiently detailed metadata (*e.g.*, exposure duration, sample type) to include in this assessment; an 8-hour TWA worker exposure concentration to DBP of 0.5 mg/m^3 from DBP production (ECB, 2004). With three aggregate or final concentration value from three sources, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the manufacturing process, the Agency used the maximum available value (1 mg/m^3). EPA assessed the midpoint of the three available values as the central tendency (0.5 mg/m^3). All three sources of monitoring data received a rating of medium from EPA's systematic review process. In absence of data specific to ONU exposure, the Agency assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. EPA assessed the exposure frequency as 250 days/year for both high-end and central tendency exposures based on the expected operating days for the OES and accounting for off days for workers.

Table 3-19 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during the incorporation into formulations, mixtures, or reaction products. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP in the form of vapor. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-19. Summary of Estimated Worker Inhalation Exposures for Incorporation into Formulations, Mixtures, or Reaction Products

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.50	1.0
	Acute Dose (AD) (mg/kg-day)	6.3E−02	0.13
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−02	9.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−02	8.6E−02
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.50	1.0
	Acute Dose (AD) (mg/kg-day)	6.9E−02	0.14
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	5.1E−02	0.10
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.7E−02	9.5E−02
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.50	0.50
	Acute Dose (AD) (mg/kg-day)	6.3E−02	6.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−02	4.6E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−02	4.3E−02

[a] EPA identified surrogate inhalation monitoring data from three sources to estimate exposures for this OES (ECB, 2008, 2004; SRC, 2001). All three sources of monitoring data received a rating of medium from EPA's systematic review process. With the three discrete data points, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the manufacturing process, the Agency used the maximum available value (1 mg/m^3). EPA assessed the midpoint of the three available values as the central tendency (0.5 mg/m^3).

3.3.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-20 are explained in Appendix A. ONU dermal exposures are not assessed for this OES as there are no activities expected to expose ONUs to DBP in liquid form. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-20 summarizes the APDR, AD, IADD, and ADD for average adult workers and female workers of reproductive age. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-20. Summary of Estimated Worker Dermal Exposures for Incorporation into Formulations, Mixtures, or Reaction Products

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	100	201
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.92	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.86	1.7
Female of Reproductive Age	Dose Rate (APDR, mg/day)	84	167
	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.85	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.79	1.6
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.3.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-21. Summary of Estimated Worker Aggregate Exposures for Incorporation into Formulations, Mixtures, or Reaction Products

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.3	2.6
	Intermediate (IADD, mg/kg-day)	0.97	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.90	1.8
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.2	2.5
	Intermediate (IADD, mg/kg-day)	0.90	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.84	1.7
ONU	Acute (AD, mg/kg-day)	6.3E−02	6.3E−02
	Intermediate (IADD, mg/kg-day)	4.6E−02	4.6E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	4.3E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.4 PVC Plastics Compounding

3.4.1 Process Description

PVC plastics compounding involves mixing the polymer with the plasticizer and other chemicals such as fillers and heat stabilizers (U.S. EPA-HQ-OPPT-218-0435-0021; EPA-HQ-OPPT-218-0435-22). The plasticizer needs to be absorbed into the particle to impart flexibility to the polymer. The 2020 CDR reports use of DBP as a plasticizer in plastic product manufacturing (see Appendix E for EPA-identified, DBP-containing products for this OES) (U.S. EPA, 2020a). CPSC found that DBP is present in the manufacturing of various plastics, typically as a catalyst, carrier, or accelerant (U.S. CPSC, 2015b).

According to the ESD on Plastic Additives, plasticizers are typically handled in bulk and processed into PVC through dry blending or plastisol blending (OECD, 2009b). Dry blending is used to make polymer blends for extrusion, injection molding, and calendaring. It involves mixing all ingredients with a high-speed rotating agitator that heats the material by friction to a maximum of 100 to 120 °C. Plastisol blending is used to make plastisol, which is a suspension of polymer particles in liquid plasticizer that can be poured into molds and heated to form the plastic. Plastisol blending involves stirring of ingredients at ambient temperature (OECD, 2009b).

Companies that reported the use of DBP as a plasticizer in plastic products in 2020 CDR report the use of DBP in liquid form. Most companies report using concentrations of at least 90 percent DBP in the plasticizers. However, one company reported the use of liquid DBP in concentrations of less than one percent, and one company reported concentrations of 60 to 90 percent DBP. (U.S. EPA, 2020a). The concentration of DBP in compounded plastic resins is unknown. Sources indicate that plasticizers are typically used at concentrations of 30 to 50 percent of the plastic material (OECD, 2009b), but may be up to 70 percent (Vainiotalo and Pfaffli, 1990). In final consumer products, the concentration of DBP is typically claimed CBI, but one report (UBE America Inc.) indicates DBP is at least 90 percent in consumer plastic product (U.S. EPA, 2020a). One literature source found that DBP identified in polypropylene is expected to be present at concentrations below 0.2 percent but could be as high as 2.7 percent (TERA, 2016). EPA assessed releases of DBP assuming 45 percent by mass as the highest expected DBP concentration based on the Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c).

Figure 3-4 provides an illustration of the plastic compounding process (U.S. EPA, 2021c).

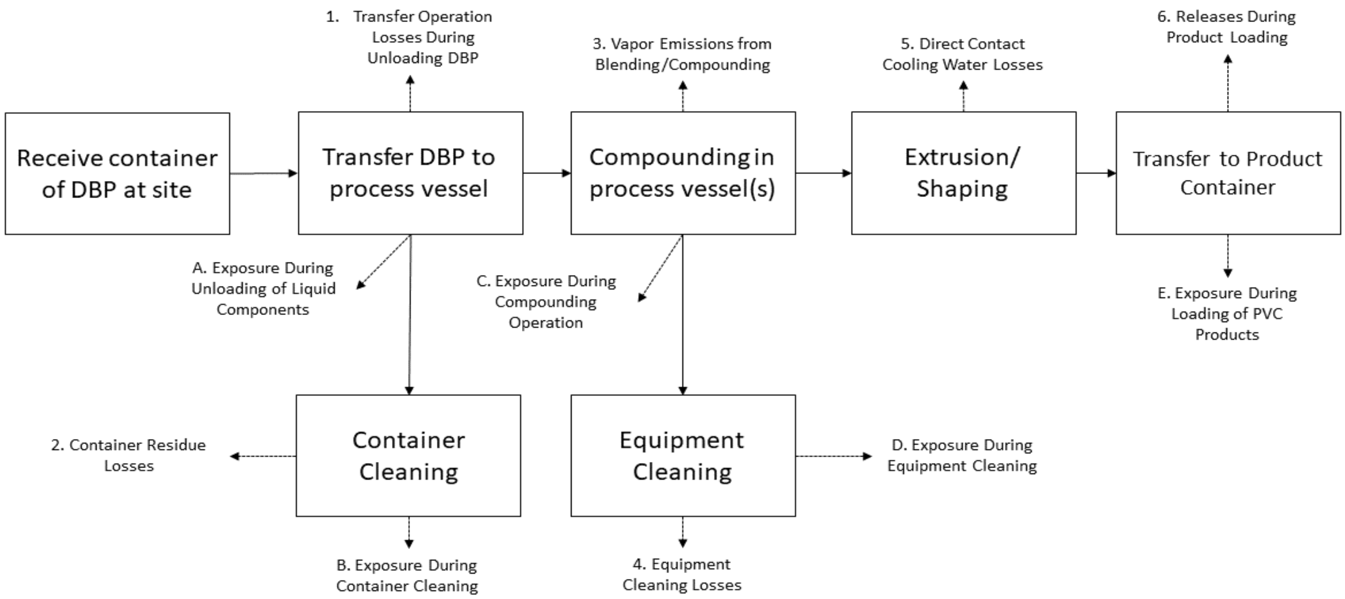


Figure 3-4. PVC Plastics Compounding Flow Diagram (U.S. EPA, 2021c)

3.4.2 Facility Estimates

In the NEI (U.S. EPA, 2023a, 2019), DMR (U.S. EPA, 2024a), and TRI (U.S. EPA, 2024e) data that EPA analyzed, EPA identified that 16 sites may have used DBP in plastic compounding based on site names and their reported NAICS and SIC codes. Due to the lack of data on the annual PV of DBP used in plastic compounding, EPA did not present annual or daily site throughputs. EPA identified one site that submitted NEI air release data that included an estimate of 364 operating days. TRI/DMR datasets do not report operating days; therefore, EPA assumed 246 days/year of operation per the Revised Plastic Compounding GS as discussed in Section 2.3.2 (U.S. EPA, 2021c).

3.4.3 Release Assessment

3.4.3.1 Environmental Release Points

Based on TRI, NEI, and DMR data, plastic compounding releases may go to fugitive air, stack air, surface water, POTW, and landfill and additional releases may occur from transfers of wastes to off-site treatment facilities (assessed in the Waste handling, treatment, and disposal OES) (U.S. EPA, 2024a, e, 2023a, 2019). Fugitive air, POTW, incineration, or landfill releases may occur from loading plastic masterbatch and unloading plastic additives. Fugitive or stack air releases may occur from blending/compounding operations. Surface water or POTW releases may occur from direct contact cooling. POTW, incineration, or landfill releases may occur from container residues and equipment cleaning. Additional fugitive air releases may occur during leakage of pipes, flanges, and accessories used for transport.

Sites may utilize air capture technology, in which case releases to incineration or landfill may occur from dust during product loading and the remaining uncontrolled dust would be released to stack air. Releases to fugitive air, POTW, incineration, or landfill may occur from dust during product loading in cases where air capture technology is not utilized.

3.4.3.2 Environmental Release Assessment Results

Table 3-22 presents fugitive and stack air releases per year and per day for the PVC plastics compounding OES based on the 2017 to 2022 TRI database years along with the number of release days per year, with medians and maxima presented from across the six-year reporting range. Table 3-23 presents fugitive and stack air releases per year and per day based on 2020 NEI database along with the number of release days per year. Table 3-24 presents water releases per year and per day based on the 2017 to 2022 DMR database along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)*, *Draft Summary of Results for Identified Environmental Releases to Land for Dibutyl Phthalate (DBP)*, and *Draft Summary of Results for Identified Environmental Releases to Water for Dibutyl Phthalate (DBP)* contain additional information about these identified releases and their original sources; refer to Appendix F for a reference to these supplemental documents.

Table 3-22. Summary of Air Releases from TRI for PVC Plastics Compounding

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Median Annual Fugitive Air Release (kg/year)	Median Annual Stack Air Release (kg/year)	Annual Release Days (days/ year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)	Median Daily Fugitive Air Release (kg/day)	Median Daily Stack Air Release (kg/day)
ITW Performance Polymers	1.4	13	1.4	10	246	5.5E−03	5.3E−02	5.5E−03	4.2E−02

Table 3-23. Summary of Air Releases from NEI (2020) for PVC Plastics Compounding

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Axiall LLC – Plaquemine Facility	6.8	N/A	364	1.9E−02	N/A

No data was reported for land releases for the PVC plastics compounding OES. EPA assessed data for Non-PVC material manufacturing as a surrogate (Table 3-37).

Table 3-24. Summary of Water Releases from DMR for PVC Plastics Compounding

Site Identity	Source-Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
AMCOL Health & Beauty Solutions Inc.	DMR- Direct Discharges	2.1E−03	8.6E−06	2.1E−03	8.6E−06	246
Braskem American Inc-LaPorte Site	DMR- Direct Discharges	5.6E−02	2.3E−04	0.28	1.1E−03	246
Chemours Company FC LLC	DMR- Direct Discharges	106	0.43	106	0.43	246
DDP Specialty Electronic Materials US LLC	DMR- Direct Discharges	0.12	4.7E−04	0.21	8.3E−04	246
Equistar Chemicals LP	DMR- Direct Discharges	0.30	1.2E−03	0.30	1.2E−03	246
Equistar Chemicals LP-Lake Charles Polymers Site	DMR- Direct Discharges	0.66	2.7E−03	0.66	2.7E−03	246
Metton America La Porte Plant	DMR- Direct Discharges	1.9E−02	7.8E−05	2.8E−02	1.2E−04	246
Neal Plant	DMR- Direct Discharges	4.1E−02	1.7E−04	6.9E−02	2.8E−04	246
Nova Chemicals Incorporated	DMR- Direct Discharges	0.26	1.0E−03	0.26	1.0E−03	246
Owensboro Specialty Polymers	DMR- Direct Discharges	3.3E−02	1.3E−04	3.3E−02	1.3E−04	246
Rohm & Haas Bristol Facility	DMR- Direct Discharges	0.63	2.5E−03	0.63	2.5E−03	246

Site Identity	Source-Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Shintech Inc	DMR- Direct Discharges	8.3	3.4E−02	8.3	3.4E−02	246
Styrolution America LLC	DMR- Direct Discharges	0.33	1.3E−03	0.33	1.3E−03	246
Total Petrochemicals & Refining USA Inc	DMR- Direct Discharges	0.64	2.6E−03	1.1	4.4E−03	246

3.4.4 Occupational Exposure Assessment

3.4.4.1 Worker Activities

Workers are potentially exposed to DBP during the compounding process via inhalation of vapor and dust or dermal contact with dust during unloading and loading, equipment cleaning, and transport container cleaning (U.S. EPA, 2021c). EPA did not identify information on engineering controls or worker PPE used at plastics compounding sites.

For this OES, ONUs may include supervisors, managers, and other employees that work in the compounding area but do not directly contact DBP that is received or processed onsite or handle the compounded plastic product. ONUs are potentially exposed via inhalation to vapors and inhalation and dermal exposures to airborne and settled dust while in the working area.

3.4.4.2 Occupational Inhalation Exposure Results

EPA did not identify chemical-specific or OES-specific inhalation monitoring data for DBP from systematic review, however, EPA utilized surrogate vapor inhalation monitoring data from PVC plastics converting to assess worker inhalation exposure to DBP vapors. The data are from a risk evaluation completed by the ECJRC, which included four data points compiled from two sources (ECB, 2004). The ECJRC risk evaluation received a rating of medium from EPA's systematic review process. All data are from unnamed facilities, with two datapoints from a facility using PVC in the manufacturing of cables (thermodegradation of PVC) and the other two datapoints summarizing a dataset listed only as from the "polymer industry." With the four discrete data points, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the converting process, EPA used the maximum available value (0.75 mg/m^3). EPA assessed the average of the four available values as the central tendency (0.24 mg/m^3).

In addition to vapor exposure, EPA expects worker inhalation exposures to DBP via exposure to particulates of plastic materials during the compounding process. To estimate worker and ONU inhalation exposure, EPA used the Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (also called "PNOR Model") (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix D. EPA used a subset of the model data that came from facilities with the NAICS code starting with 326 – Plastics and Rubber Manufacturing to estimate plastic particulate concentrations in the air. For this OES, EPA identified 45 percent by mass as the highest expected DBP concentration based on the Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c). The estimated exposures assume that DBP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. EPA used the number of operating days estimated in the release assessment for this OES to estimate exposure frequency, which is the expected maximum number of working days. EPA assessed the exposure frequency as 250 days/year for both high-end and central tendency exposures based on the expected operating days for the OES and accounting for off days for workers.

Table 3-25 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker and ONU exposures to DBP during the plastics compounding process. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP primarily in the form of particulates, but also accounts for other potential inhalation exposure routes, such as from the inhalation of vapors. Based on the low vapor pressure of DBP, exposure to vapors is not expected to be a major contribution to exposures. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data, information on the PNOR Model parameters used, and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-25. Summary of Estimated Worker Inhalation Exposures for Plastics Compounding

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.34	2.9
	Acute Dose (AD) (mg/kg-day)	4.3E−02	0.36
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.1E−02	0.26
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.9E−02	0.25
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.34	2.9
	Acute Dose (AD) (mg/kg-day)	4.7E−02	0.40
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.5E−02	0.29
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.2E−02	0.27
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.34	0.34
	Acute Dose (AD) (mg/kg-day)	4.3E−02	4.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.1E−02	3.1E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.9E−02	2.9E−02
[a] EPA utilized surrogate vapor inhalation monitoring data from PVC plastics converting to assess worker inhalation exposure to DBP vapors. The data is from a risk evaluation completed by the ECJRC, which included four data points compiled from two sources (ECB, 2004). The ECJRC risk evaluation received a rating of medium from EPA's systematic review process. To assess the high-end worker exposure to DBP, EPA used the maximum available value (0.75 mg/m^3). EPA assessed the average of the four available values as the central tendency (0.24 mg/m^3). EPA used			

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
the PNOR Model to estimate exposures to dust. For the PNOR Model, EPA multiplied the concentration of DBP with the central tendency and HE estimates of the relevant NAICS code from the PNOR Model to calculate the central tendency and HE estimates for this OES.			

3.4.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-26 are explained in Appendix A. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate an estimate of exposure. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-26 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-26. Summary of Estimated Worker Dermal Exposures for Plastics Compounding

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	102	204
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.93	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.87	1.7
Female of Reproductive Age	Dose Rate (APDR, mg/day)	85	169
	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.86	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.80	1.6
ONU	Dose Rate (APDR, mg/day)	1.4	1.4
	Acute Dose (AD) (mg/kg/day)	1.7E−02	1.7E−02
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	1.2E−02	1.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg/day)	1.2E−02	1.2E−02
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.4.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-27. Summary of Estimated Worker Aggregate Exposures for Plastics Compounding

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.3	2.9
	Intermediate (IADD, mg/kg-day)	0.96	2.1
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.90	2.0
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.2	2.7
	Intermediate (IADD, mg/kg-day)	0.89	2.0
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.83	1.9
ONU	Acute (AD, mg/kg-day)	6.0E−02	6.0E−02
	Intermediate (IADD, mg/kg-day)	4.4E−02	4.4E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.1E−02	4.1E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.5 PVC Plastics Converting

3.5.1 Process Description

DBP is used as a plasticizer in plastics (see Appendix E for EPA-identified DBP-containing products for this OES). EPA expects that DBP in compounded resins will arrive at a typical converting site as a solid in containers of different sizes(U.S. EPA, 2004a). After the compounding process described in 3.4.1, compounded plastic resins are converted into solid plastic articles. According to the ESD on Plastic Additives, compounded resin can be converted into final products through many processes, including closed processes such as extrusion, injection molding, compression molding, extrusion blow molding, partially open processes such as film extrusion, and open processes including, calendaring, thermoforming, and fiber reinforced plastic fabrication (OECD, 2009b). Vapor (fume) elimination equipment is commonly used during these processes (OECD, 2009b).

During extrusion, heated plastic resin is forced through a die and then quenched to form products such as pipe, profiles, sheets, and wire coating. Injection molding involves heated plastic resin which is injected into a cold mold where the plastic takes the shape of the mold as it solidifies. Compression molding is the main process used for thermosetting materials. This process is performed by inserting prepared compound into a mold which is closed and maintained under pressure during a heating cycle. In extrusion blow molding, an extruder delivers a tubular extrudate between two halves of a mold joined around the hot extrudate before air is blown through, forcing the polymer to meld against the sides of the mold. The high-speed process is used to manufacture packaging bottles and containers (OECD, 2009b).

During film extrusion, a film is cooled by travelling upwards over a vertical bubble of air before being taken up onto reels or extruded through a slit die and immediately quenched. In calendaring, heated plastic resin is fed onto rolls that compress the material into a thin layer to form sheets and films. With thermoforming, a plastic sheet is locked in a frame and heated to the forming temperature then brought into contact with a mold of the desired shape. The sheet may be drawn onto the form using vacuum or applied pressure. If the sheets are extruded on site rather than being brought in, the process may be continuous. Fiber reinforced plastic fabrication involves unsaturated polyester resins and reinforcements cured at ambient temperatures or with small amounts of heat. This process may fabricate large shapes by using hand lay up or spray techniques to deposit resin and reinforcements onto a mold for curing. Filament winding may also be used to deposit resin and reinforcements onto a rotating mandrel before being introduced to an oven for heating (OECD, 2009b).

In some cases, after converting into the desired shape, the plastic product may undergo subsequent trimming to remove excess material (OECD, 2009b). Other finishing operations, such as paint, coating, and bonding may occur (these are covered under other COUs). Plasticizers are not chemically bound to the polymer and are able to migrate to the surface (OECD, 2009b).

The concentration of DBP in compounded plastic resins is unknown. Sources indicate that plasticizers are typically used at concentrations of 20 to 40 percent of the plastic material (Chao et al., 2015; Xu et al., 2010), but may be up to 60 percent (Gaudin et al., 2011; Gaudin et al., 2008). EPA did not identify other sources with information on DBP concentration in plastic products.

Figure 3-5 provides an illustration of the plastic converting process (U.S. EPA, 2004a).

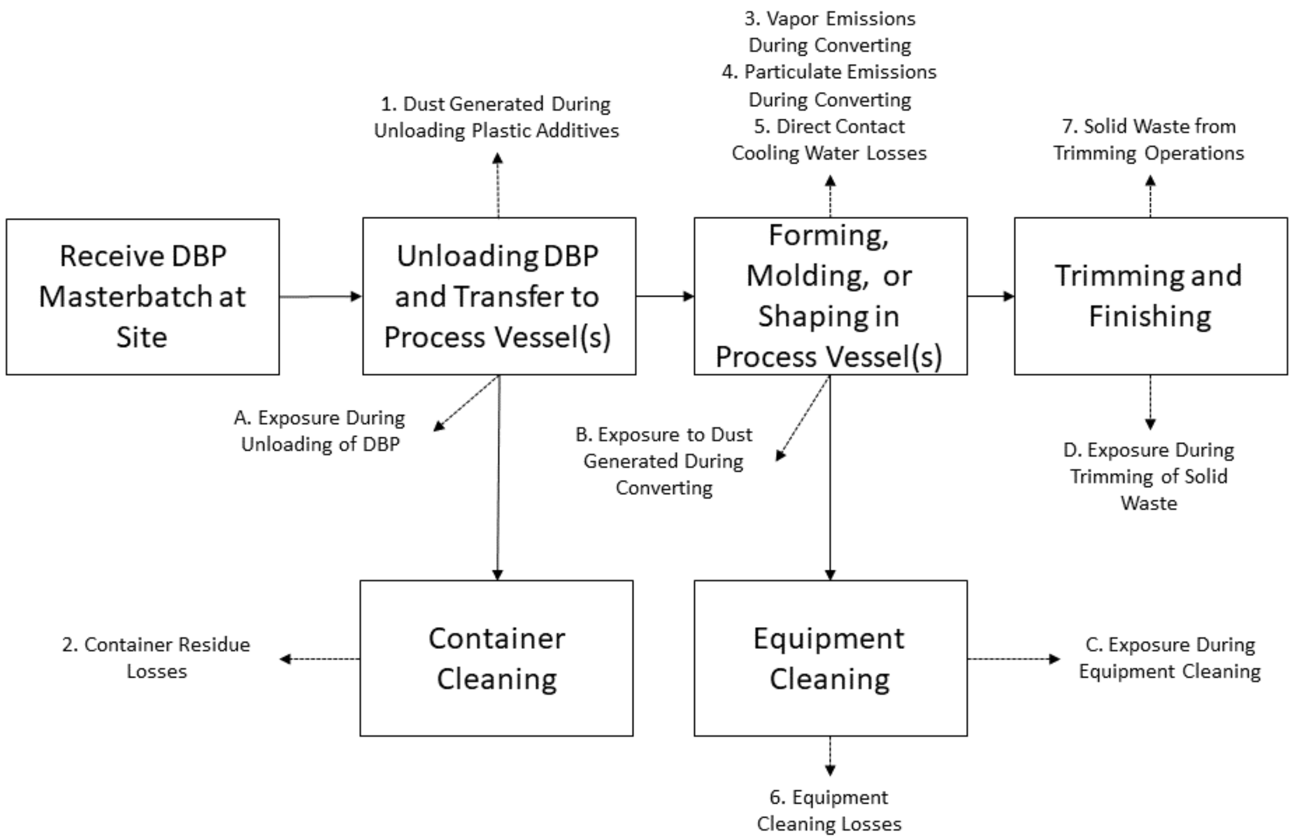


Figure 3-5. PVC Plastics Converting Flow Diagram (U.S. EPA, 2021d)

3.5.2 Facility Estimates

In the NEI (U.S. EPA, 2023a, 2019), DMR (U.S. EPA, 2024a), and TRI (U.S. EPA, 2024e) data that EPA analyzed, EPA identified 8 sites that have possibly used DBP in PVC plastics converting based on site names and their reported NAICS and SIC codes. Two CDR reporters indicated the use of DBP for

Plastics Product Manufacturing in the 2020 CDR. EPA identified operating days ranging from 253 to 260 with an average of 256 days through NEI air release data. TRI/DMR (U.S. EPA, 2024a) datasets did not report operating days; therefore, EPA used 253 days/year of operation according to the Revised Plastic Converting GS as discussed in Section 2.3.2 (U.S. EPA, 2014c).

The ESD on Plastic Additives estimates 341 to 3,990 metric tons of flexible PVC produced per site per year (341,000 to 3,990,000 kg/site-year) (OECD, 2009b). This production range is not used to estimate releases because of the availability of environmental release data reported by facilities for this OES. A typical number of production days during a year is 148 to 264 days (U.S. EPA, 2014b). Assuming a concentration of DBP in the plastic of 30 to 45 percent (see PVC plastics compounding section) and 264 days/year, this results in a use rate of 388 to 12,131 kg/site-day and 102,300 to 1,795,500 kg/site-year.

3.5.3 Release Assessment

3.5.3.1 Environmental Release Points

EPA assigned release points based on NEI/TRI data for air releases (U.S. EPA, 2024e, 2023a, 2019). There was no identified data for water and land releases for this OES, so these releases were assessed using data for Non-PVC Material Manufacturing (Table 3-37 and Table 3-38). Potential sites might not have reported water and land releases because the releases from the facilities might have been below the threshold required to report to the databases.

EPA assessed potential release points based on the 2021 Use of Additives in Plastics Converting Draft Generic Scenario (U.S. EPA, 2021d). Releases of dust to stack air, fugitive air, wastewater, incineration, or landfill are expected while unloading plastic additives. EPA expects converting operations to release vapor emissions to fugitive or stack air and particulate emissions to fugitive air, wastewater, incineration, or landfill. EPA expects releases to wastewater, incineration, or landfill from container residues and equipment cleaning. EPA expects releases to wastewater from direct contact cooling and incineration and landfill releases from solid waste trimming.

Converting sites may utilize air capture technology. If a site uses air capture technology, EPA expects dust releases from unloading plastic additives during transfer operations to be controlled and released to disposal facilities for incineration or landfill. The site would release the remaining uncontrolled dust to stack air. If the site does not use air control technology, EPA expects plastic unloading releases to fugitive air, water, incineration, or landfill as described above.

3.5.3.2 Environmental Release Assessment Results

Table 3-28 presents fugitive and stack air releases per year and per day for plastic converting based on the 2017 to 2022 TRI database years along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. Table 3-29 presents fugitive and stack air releases per year and per day based on 2020 NEI database along with the number of release days per year. Table 3-30 presents fugitive and stack air releases per year and per day based on 2017 NEI database along with the number of release days per year. The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)*, *Draft Summary of Results for Identified Environmental Releases to Land for Dibutyl Phthalate (DBP)*, and *Draft Summary of Results for Identified Environmental Releases to Water for Dibutyl Phthalate (DBP)* contain additional information about these identified releases and their original sources; refer to Appendix F for a reference to these supplemental documents.

Table 3-28. Summary of Air Releases from TRI for PVC Plastics Converting

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Median Annual Fugitive Air Release (kg/year)	Median Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)	Median Daily Fugitive Air Release (kg/day)	Median Daily Stack Air Release (kg/day)
Premold Corp	0.45	0	0.45	0	253	1.8E−03	0	1.8E−03	0

Table 3-29. Summary of Air Releases from NEI (2020) for PVC Plastics Converting

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Armstrong Flooring Inc	N/A	53	253	N/A	0.21
Polyurethane Molding Ind, Inc.	2.2	N/A	253	8.6E−03	N/A
Ampac Flex LLC	N/A	58	253	N/A	0.23
Real Fleet Solutions, LLC	0	N/A	260	0	N/A
Graham Packaging LC LP Plant 0176	0.15	N/A	260	5.8E−04	N/A

Table 3-30. Summary of Air Releases from NEI (2017) for PVC Plastics Converting

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Novolex Shields, LLC	0	0	253	0	0
Formed Fiber Technologies, LLC – Auburn	3.4E−02	N/A	253	1.4E−04	N/A

No water release or land release data was identified for the PVC plastics converting OES. EPA assessed water release data for this OES using the PVC plastics compounding OES as a surrogate (Table 3-24). EPA assessed land release data for this OES using the Non-PVC material manufacturing OES as a surrogate (Table 3-37).

3.5.4 Occupational Exposure Assessment

3.5.4.1 Worker Activities

Worker exposures to DBP during the converting process occur via inhalation to vapors generated from materials and elevated temperatures and inhalation of dust or dermal contact with dust during unloading and loading, transport container cleaning, equipment cleaning, and trimming of excess plastic (U.S. EPA, 2021d). EPA did not identify information on engineering controls or worker PPE used at DBP-containing PVC plastics converting sites.

ONUs include supervisors, managers, and other employees that work in the PVC converting area but do directly contact the DBP-containing PVC material that is received or handle the finished product or article. ONUs are potentially exposed to airborne and settled dust via inhalation and dermal routes while in the working area.

3.5.4.2 Occupational Inhalation Exposure Results

EPA identified vapor inhalation monitoring data from a risk evaluation completed by the ECJRC, which included four data points compiled from two sources (ECB, 2004). The ECJRC risk evaluation received a rating of medium from EPA's systematic review process. All data is from unnamed facilities, with two datapoints from a facility using PVC in the manufacturing of cables and the other two datapoints summarizing a dataset listed only as from the "polymer industry." With the four discrete data points, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the converting process, EPA used the maximum available value (0.75 mg/m^3). EPA assessed the average of the four available values as the central tendency (0.24 mg/m^3).

EPA also expects worker inhalation exposures to DBP via exposure to particulates of plastic materials during the compounding process in addition to DBP unloading and loading tasks, container cleaning, and equipment cleaning. To estimate worker and ONU inhalation exposure, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix D. EPA used a subset of the model data that came from facilities with the NAICS code starting with 326 – Plastics and Rubber Manufacturing to estimate plastic particulate concentrations in the air. For this OES, EPA identified 45 percent by mass as the highest expected DBP concentration based on the Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c). The estimated exposures assume that DBP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. EPA assessed the exposure frequency as 250 days/year for both high-end and central tendency exposures based on the expected operating days for the OES and accounting for off days for workers.

Table 3-31 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during PVC plastics converting. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP primarily in the form of particulates, but also accounts for other potential inhalation exposure routes, such as from the inhalation of vapors. Based on the low vapor pressure of DBP, exposure to vapors is not expected to be a major contribution to exposures. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data, information on the PNOR Model parameters used, and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-31. Summary of Estimated Worker Inhalation Exposures for PVC Plastics Converting

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration(mg/m^3)	0.34	2.9
	Acute Dose (AD) (mg/kg-day)	4.3E−02	0.36
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.1E−02	0.26
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.9E−02	0.25
Female of Reproductive Age	8-hour TWA Exposure Concentration(mg/m^3)	0.34	2.9
	Acute Dose (AD) (mg/kg-day)	4.7E−02	0.40
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.5E−02	0.29
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.2E−02	0.27
ONU	8-hour TWA Exposure Concentration(mg/m^3)	0.34	0.34

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
	Acute Dose (AD) (mg/kg-day)	4.3E−02	4.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.1E−02	3.1E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.9E−02	2.9E−02

[a] EPA utilized vapor inhalation monitoring data to assess worker inhalation exposure to DBP vapors. The data is from a risk evaluation completed by the ECJRC, which included four data points compiled from two sources (ECB, 2004). The ECJRC risk evaluation received a rating of medium from EPA's systematic review process. To assess the high-end worker exposure to DBP, EPA used the maximum available value (0.75 mg/m^3). EPA assessed the average of the four available values as the central tendency (0.24 mg/m^3). EPA used the PNOR Model to estimate exposures to dust. For the PNOR Model, EPA multiplied the concentration of DBP with the central tendency and HE estimates of the relevant NAICS code from the PNOR Model to calculate the central tendency and HE estimates for this OES.

3.5.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-32 are explained in Appendix A. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-32 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-32. Summary of Estimated Worker Dermal Exposures for PVC Plastics Converting

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	1.4	2.7
	Acute (AD, mg/kg-day)	1.7E−02	3.4E−02
	Intermediate (IADD, mg/kg-day)	1.2E−02	2.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−02	2.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	1.1	2.3
	Acute (AD, mg/kg-day)	1.6E−02	3.1E−02
	Intermediate (IADD, mg/kg-day)	1.1E−02	2.3E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.1E−02	2.1E−02
ONU	Dose Rate (APDR, mg/day)	1.4	1.4
	Acute Dose (AD) (mg/kg/day)	1.7E−02	1.7E−02
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	1.2E−02	1.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg/day)	1.2E−02	1.2E−02
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.5.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-33. Summary of Estimated Worker Aggregate Exposures for PVC Plastics Converting

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	6.0E−02	0.39
	Intermediate (IADD, mg/kg-day)	4.4E−02	0.29
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.1E−02	0.27
Female of Reproductive Age	Acute (AD, mg/kg-day)	6.3E−02	0.43
	Intermediate (IADD, mg/kg-day)	4.6E−02	0.31
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	0.29
ONU	Acute (AD, mg/kg-day)	6.0E−02	6.0E−02
	Intermediate (IADD, mg/kg-day)	4.4E−02	4.4E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.1E−02	4.1E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.6 Non-PVC Material Manufacturing (Compounding and Converting)

3.6.1 Process Description

2020 CDR reporters indicate DBP use in non-PVC polymers, such as rubber or non-PVC resins and as an intermediate in rubber product manufacturing (U.S. EPA, 2020a). EPA identified three product safety data sheets (SDSs) for resins used for casting plastic products, all three contained DBP concentrations between 1 to 5 percent (BJB Enterprises, 2021, 2019, 2016) (see Appendix E for EPA-identified, DBP-containing products for this OES).

EPA expects that a typical non-PVC material compounding site operates similar to a plastic compounding site. Typical compounding sites receive and unload DBP and transfer it into mixing vessels to produce a compounded resin masterbatch. Following completion of the masterbatch, sites transfer the solid resin to extruders that shape and size the plastic and package the final product for shipment to downstream conversion sites after cooling (U.S. EPA, 2021c). Figure 3-6 provides an illustration of the plastic compounding process (U.S. EPA, 2021c; ESIG, 2020b; OECD, 2004a).

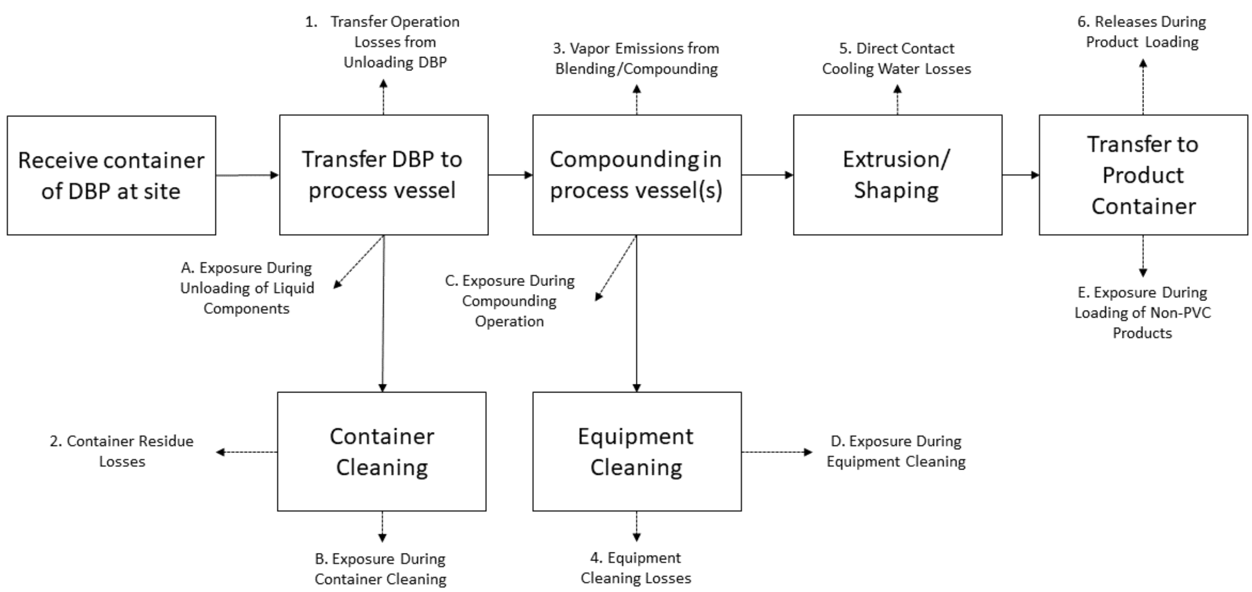


Figure 3-6. Non-PVC Material Compounding Flow Diagram (U.S. EPA, 2021c)

Note that some materials, such as rubbers, may be formulated via a consolidated compounding and converting operation, as described in the *SpERC Fact Sheet on Rubber Production and Processing*. Figure 3-7 provides an illustration of the rubber formulation process (ESIG, 2020b; OECD, 2004a). However, the rate of consolidated operations for non-PVC materials is unknown; therefore, EPA assessed all formulations as separate compounding and converting steps. Figure 3-7 provides an illustration of the consolidated process.

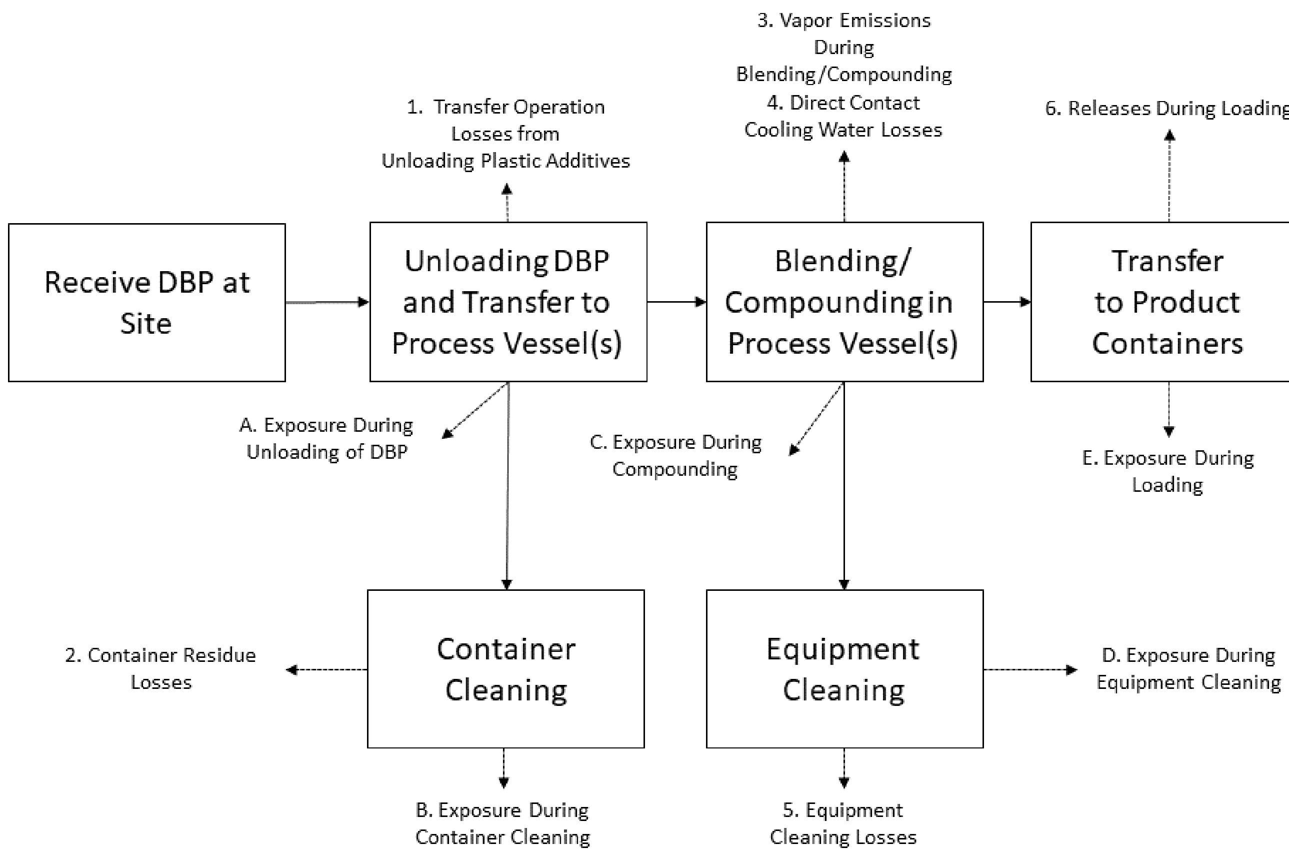


Figure 3-7. Consolidated Compounding and Converting Flow Diagram Facility Estimates

3.6.2 Facility Estimates

In the NEI (U.S. EPA, 2023a, 2019), DMR (U.S. EPA, 2024a), and TRI (U.S. EPA, 2024e) data that EPA analyzed, EPA identified that 54 sites may have released DBP from manufacturing non-PVC materials based on site names and their reported NAICS and SIC codes. No sites were reported under CDR. Due to the lack of data on the annual PV of DBP in non-PVC material manufacturing, EPA did not present annual or daily site throughputs. EPA identified information on operating days in the NEI air release data. Operating days ranged from 20 to 365 days per year, with an average of 298 days. TRI/DMR (U.S. EPA, 2024a) datasets do not report operating days; therefore, EPA assumed 250 days/year of operation as discussed in Section 2.3.2.

3.6.3 Release Assessment

3.6.3.1 Environmental Release Points

EPA analyzed releases based on NEI/TRI data (U.S. EPA, 2024e, 2023a, 2019). EPA expects blending and compounding operations to release vapor emissions to fugitive or stack air. EPA expects releases to water, incineration, or landfill from container residues and equipment cleaning wastes. EPA expects releases to water from direct contact cooling. Releases to fugitive air, water, incineration, or landfill are expected during transfer operations and while loading plastic additives.

Sites may utilize air capture technology. If a site uses air capture technology, EPA expects dust releases from product loading to be controlled and released to disposal facilities for incineration or landfill. EPA expects the remaining uncontrolled dust to be released to stack air. If the site does not use air control technology, EPA expects releases to fugitive air, wastewater, incineration, or landfill as described above.

3.6.3.2 Environmental Release Assessment Results

Table 3-34 presents fugitive and stack air releases per year and per day for non-PVC material manufacturing based on the 2017 to 2022 TRI database years along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. Table 3-35 presents fugitive and stack air releases per year and per day based on 2020 NEI database along with the number of release days per year. Table 3-36 presents fugitive and stack air releases per year and per day based on 2017 NEI database along with the number of release days per year. Table 3-37 presents land releases per year based on the TRI database along with the number of release days per year. Table 3-38 presents water releases per year and per day based on the 2017 to 2022 TRI database along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)*, *Draft Summary of Results for Identified Environmental Releases to Land for Dibutyl Phthalate (DBP)*, and *Draft Summary of Results for Identified Environmental Releases to Water for Dibutyl Phthalate (DBP)* contain additional information about these identified releases and their original sources; refer to Appendix F for a reference to these supplemental documents.

Table 3-34. Summary of Air Releases from TRI for Non-PVC Plastics Manufacturing

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Median Annual Fugitive Air Release (kg/year)	Median Annual Stack Air Release (kg/year)	Annual Release Days (days/ year)	Maximum Daily Fugitive Air Release (kg/year)	Maximum Daily Stack Air Release (kg/day)	Median Daily Fugitive Air Release (kg/day)	Median Daily Stack Air Release (kg/day)
Danfoss-Mountain Home	2.3	5.4	0	3.8	250	9.1E−03	2.2E−02	0	1.5E−02
Belt Concepts of America Inc	0	34	0	30	250	0	0.14	0	0.12
Danfoss Power Solutions II LLC	59	5.4	27	4.7	250	0.23	2.2E−02	0.11	1.9E−02
Parker Hannifin	0.95	2.9E−04	0.48	1.5E−04	250	3.8E−03	1.2E−06	1.9E−03	5.8E−07

Table 3-35. Summary of Air Releases from NEI (2020) for Non-PVC Plastics Manufacturing

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
BFGoodrich Tire Co	21	8.8E−03	287	7.2E−02	3.1E−05
The Cooper Tire Company	174	0	322	0.54	0
Goodyear Tire & Rubber Company	N/A	0	321	N/A	0
Boston Weatherhead	N/A	2.8	287	N/A	9.7E−03
Michelin Na US5/US7 Lexington	N/A	3.5	343	N/A	1.0E−02
Michelin: Anderson US8	N/A	1.4E−05	302	N/A	4.5E−08
Michelin Na US3 Spartanburg	N/A	7.8E−02	300	N/A	2.6E−04
Bridgestone Americas Tire Operations, LLC – Warren Plant	N/A	171	287	N/A	0.59
Michelin Na US1 Greenville	6.2E−02	64	283	2.2E−04	0.23
Bridgestone Americas Tire Operations, LLC – Lavergne	27	N/A	287	9.4E−02	N/A
Henniges Automotive Sealing Systems Na Danny Scott Drive	1.1	N/A	287	3.8E−03	N/A
Contitech USA Inc	N/A	0	365	0	0
Cooper Tire and Rubber Company, Clarksdale	1.3	28	287	4.4E−03	9.9E−02
Michelin Tire Corporation	16	0	287	5.7E−02	0
Goodyear Lawton	144	0	336	0.43	0
Timken SMO LLC Springfield	1.0	4.3	287	3.6E−03	1.5E−02
The Goodyear Tire & Rubber Company	2.3	0	287	7.8E−03	0
Saint-Gobain SGPPL	9.1E−02	N/A	287	3.2E−04	N/A
Oliver Rubber Company, LLC	1.8E−02	359	343	5.3E−05	1.05
Dana Sealing Products, LLC	0.11	N/A	287	3.7E−04	N/A
Fulflex Inc	5.9	N/A	287	2.1E−02	N/A
The Cooper Tire Company	90	2.5	287	0.31	8.8E−03
Goodyear Tire & Rubber	26	4.5	350	7.3E−02	1.3E−02
Bridgestone-Bandag, LLC	N/A	79	364	0	0.22
The Goodyear Tire & Rubber Company	0.16	8.1E−06	364	4.4E−04	2.2E−08
Bridgestone Americas Tire Operations, LLC	27	1.4	250	0.11	5.8E−03
Michelin Na US2 Sandy Springs	N/A	2.2E−02	262	N/A	8.6E−05
Michelin Aircraft Tire Company	N/A	0	364	N/A	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Goodyear Dunlop Tires North America Ltd	8.0	344	287	2.8E−02	1.20
Belt Concepts of America Inc.	N/A	54	287	N/A	0.19
Brannon Tire	3.5E−04	N/A	260	1.4E−06	N/A
Industrial Rubber Applicators	N/A	0	287	N/A	0
Continental Tire the Americas LLC	N/A	177	365	N/A	0.48
Michelin North America Inc US10	N/A	5.7	335	N/A	1.7E−02
Giti Tire Manufacturing Co USA Ltd	4.0	N/A	329	1.2E−02	N/A
Yokohama Tire Manufacturing Mississippi	1.6	N/A	287	5.7E−03	N/A
Les Schwab Production Center	2.2	0	287	7.8E−03	0
Superior Tire Service, Inc.	N/A	0	287	N/A	0
Ultimate Rb, Inc.	N/A	0	287	N/A	0

Table 3-36. Summary of Air Releases from NEI (2017) for Non-PVC Plastics Manufacturing

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Fluid Routing Systems, Inc.	1.4	N/A	154	9.4E−03	N/A
Eaton Aeroquip Inc	N/A	0	287	N/A	0
Michelin Na US5 & US7 Lexington	N/A	0.22	328	N/A	6.6E−04
Michelin Na US8 Starr Facility	N/A	0.10	287	N/A	3.5E−04
Titan Tire Corporation of Union City	1.2E−02	N/A	287	4.2E−05	N/A
Cooper Tire and Rubber Company Clarksdale	1.5	0	329	4.7E−03	0
Snider Tire, Inc.	N/A	27	260	N/A	0.10
Parrish Tire Company	1.1E−02	3.2	255	4.3E−05	1.3E−02
Airboss Rubber Compounding (NC) Inc.	N/A	0	250	N/A	0
Bridgestone Aircraft Tire (USA), Inc.	0.38	9.0	250	1.5E−03	3.6E−02
Patch Rubber Company	0.23	0	250	9.1E−04	0
Industrial Rubber Applicators Inc	N/A	53	287	N/A	0.18
Snider Tire, Inc. Dba Snider Fleet Sol	N/A	0	260	N/A	0
Cooper Standard – Woodland Church Road	5.4E−02	N/A	364	1.5E−04	N/A

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Giti Tire Manufacturing USA	1.3	N/A	287	4.5E−03	N/A

Table 3-37. Summary of Land Releases from TRI for Non-PVC Plastics Manufacturing

Site Identity	Median Annual Release (kg/year)	Maximum Annual Release (kg/year)	Annual Release Days (days/year)
Danfoss Power Solutions II LLC	491	566	250
Parker Hannifin	2.3	2.3	250
Danfoss-Mountain Home	2.7	2.7	250

Table 3-38. Summary of Water Releases from TRI for Non-PVC Plastic Manufacturing

Site Identity	Source-Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Danfoss-Mountain Home	TRI Form R	4.5E−03	1.8E−05	4.5E−03	1.8E−05	250
Danfoss-Mountain Home	TRI Form R – Transfer to POTW	4.5E−03	1.8E−05	4.5E−03	1.8E−05	250

3.6.4 Occupational Exposure Assessment

3.6.4.1 Worker Activities

Worker exposures during the compounding and converting process may occur via inhalation of vapors formed during operations that occur at elevated temperatures or inhalation or dermal contact with dust during unloading and loading, equipment cleaning, and transport container cleaning (U.S. EPA, 2021c). EPA did not identify site-specific information on engineering controls or worker PPE used at DBP-containing non-PVC plastics compounding sites.

ONUs may include supervisors, managers, and other employees that work in the formulation area but do not directly contact DBP that is received or processed onsite or handle compounded product. ONUs are potentially exposed via inhalation and dermal routes to airborne and settled dust while in the working area.

3.6.4.2 Occupational Inhalation Exposure Results

EPA did not identify chemical- or OES-specific inhalation monitoring data for DBP from systematic review, however, EPA utilized surrogate vapor inhalation monitoring data from PVC plastics converting to assess worker inhalation exposure to DBP vapors. The data is from a risk evaluation completed by the ECJRC, which included four data points compiled from two sources (ECB, 2004). The ECJRC risk evaluation received a rating of medium from EPA's systematic review process. All data is from unnamed facilities, with two datapoints from a facility using PVC in the manufacturing of cables and the other two datapoints summarizing a dataset listed only as from the "polymer industry". With the four discrete data points, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the converting process, the Agency used the maximum available value (0.75 mg/m^3). EPA assessed the average of the four available values as the central tendency (0.24 mg/m^3).

In addition to vapor exposure, EPA expects worker inhalation exposures to DBP via exposure to particulates of non-PVC materials during the compounding and converting processes. Additionally, exposures to DBP are expected during unloading and loading tasks, container cleaning, and equipment cleaning. To estimate worker and ONU inhalation exposure, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix D. The Agency used a subset of the model data that came from facilities with NAICS codes starting with 326 – Plastics and Rubber Manufacturing to estimate DBP-containing, non-PVC material particulate concentrations in the air. For this OES, EPA selected 20 percent by mass as the highest expected DBP concentration based on the Emission Scenario Document on Additives in Rubber Industry (OECD, 2004a)to estimate the concentration of DBP present in particulate formed at the compounding and converting site. The estimated exposures assume that DBP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. EPA assessed the exposure frequency as 250 days/year for both high-end and central tendency exposures based on the expected operating days for the OES and accounting for off days for workers.

Table 3-39 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during non-PVC material compounding. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP primarily in the form of particulates, but also accounts for other potential inhalation exposure routes, such as from the inhalation of vapors. Based on the low vapor pressure of DBP, exposure to vapors is not expected to be a major contribution to exposures. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data, information on the PNOR Model parameters used, and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-39. Summary of Estimated Worker Inhalation Exposures for Non-PVC Material Compounding

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	100	201
	Acute Dose (AD) (mg/kg-day)	3.6E−02	0.21
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.6E−02	0.15
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.4E−02	0.14
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	84	167
	Acute Dose (AD) (mg/kg-day)	3.9E−02	0.23
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.9E−02	0.17
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.7E−02	0.16
ONU	8-hour TWA Exposure Concentration (mg/m^3)	1.5	1.5
	Acute Dose (AD) (mg/kg-day)	3.6E−02	3.6E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	2.6E−02	2.6E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	2.4E−02	2.4E−02

[a] EPA utilized surrogate vapor inhalation monitoring data from PVC plastics converting to assess worker inhalation exposure to DBP vapors. The data is from a risk evaluation completed by the ECJRC, which included four data points compiled from two sources (ECB, 2004). The ECJRC risk evaluation received a rating of medium from EPA's systematic review process. To assess the high-end worker exposure to DBP, EPA used the maximum available value (0.75 mg/m^3). EPA assessed the average of the four available values as the central tendency (0.24 mg/m^3). EPA used the PNOR Model to estimate exposures to dust. For the PNOR Model, EPA multiplied the concentration of DBP with the central tendency and HE estimates of the relevant NAICS code from the PNOR Model to calculate the central tendency and HE estimates for this OES.

3.6.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-40 are explained in Appendix A. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. Therefore, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper PPE or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-40 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-40. Summary of Estimated Worker Dermal Exposures for Non-PVC Material Compounding

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	102	204
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.93	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.87	1.7
Female of Reproductive Age	Dose Rate (APDR, mg/day)	85	169
	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.86	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.80	1.6
ONU	8-hour TWA Exposure Concentration (mg/m^3)	1.4	1.4
	Acute Dose (AD) (mg/kg/day)	1.7E−02	1.7E−02
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	1.2E−02	1.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg/day)	1.2E−02	1.2E−02
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.6.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-41. Summary of Estimated Worker Aggregate Exposures for Non-PVC Material Compounding

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.3	2.8
	Intermediate (IADD, mg/kg-day)	0.96	2.0
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.90	1.9
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.2	2.6
	Intermediate (IADD, mg/kg-day)	0.89	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.83	1.8
ONU	Acute (AD, mg/kg-day)	5.3E−02	5.3E−02
	Intermediate (IADD, mg/kg-day)	3.9E−02	3.9E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.9E−02	1.9E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.7 Application of Adhesives and Sealants

3.7.1 Process Description

DBP is used as an additive in adhesive and sealant products for industrial and commercial use, including floor sealants and adhesive and sealant chemicals used in construction (U.S. EPA, 2020b). One industry commenter provided descriptions of their DBP use in pedigreed adhesives used in testing test articles and human-rated spaceflight hardware (U.S. EPA-HQ-OPPT-2018-0503-0035). DBP is expected to arrive on site as an additive in liquid adhesive or sealant formulations. All identified products are in liquid form, and the application site receives the final formulation as a single-component adhesive/sealant product. The liquid product arrives at the site in containers ranging in size from 5 to 20 gallons and at concentrations of 0.1 to 75 percent DBP (see Appendix E for EPA identified-DBP-containing products for this OES). The size of the container is an input to the Monte Carlo simulation to estimate releases but is not used to calculate occupational exposures for DBP. The application site directly transfers the liquid product to the application equipment to apply it as the final adhesive/sealant to the substrate (OECD, 2015).

Application methods for the final adhesive/sealant include spray, roll, dip, curtain, bead, roll, and syringe application. Application may occur over the course of an 8-hour workday at a given site, accounting for drying or curing times and additional coats where necessary. The site may trim excess adhesive/sealant from the applied substrate area. Figure 3-8 provides an illustration of the process of applying adhesives and sealants (OECD, 2015).

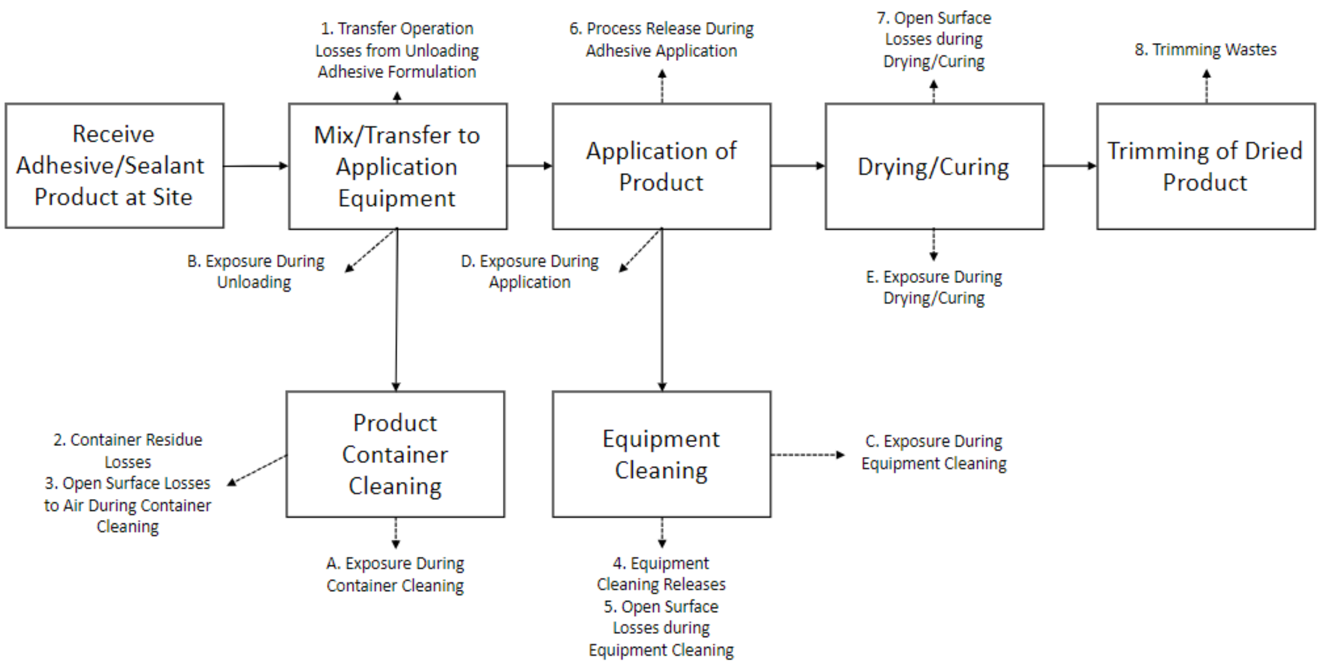


Figure 3-8. Application of Adhesives and Sealants Flow Diagram

3.7.2 Facility Estimates

EPA estimated the total DBP production volume for adhesive and sealant products using a uniform distribution with a lower-bound of 99,157 kg/year and an upper-bound of 2,140,323 kg/year. This range is based on DBP CDR data of site production volumes, national aggregate production volumes, and percentages of the production volumes going to various industrial sectors (U.S. EPA, 2020a).

There were two reporters that reported to CDR for use of DBP in adhesive/sealant or paint/coating products: G.J. Chemical Co, Inc. in Somerset, New Jersey, who reported a volume of 139,618 lb; and MAK Chemicals in Clifton, NJ, who reported a use volume of 105,884 lb of DBP. This equates to a total known use volume of 245,502 lb of DBP; however, there is still a large portion of the aggregate PV range for DBP that is not attached to a known use. A breakdown of the known production volume information is provided in Table_Apx D-7.

Due to uncertainty in the expected use of DBP, EPA assumes that the remaining PV with unknown use is split between the use of adhesives and sealants and paint and coating products. Subtracting the PV with known uses that are not associated with adhesives/sealants/paints/coatings from the aggregate national PV range equates to a range of 99,157 to 2,140,323 kg for this OES (see Section D.3.3). EPA used the range of production volumes as an input to the Monte Carlo modeling described in Appendix D to estimate releases. The production volume range is not used to calculate occupational exposures for DBP.

EPA did not identify site- or chemical-specific adhesive and sealant application operating data (*i.e.*, facility use rates). However, the 2015 ESD on the Use of Adhesives estimated an adhesive use rate of 1,500 to 141,498 kg/site-year. Based on DBP concentration in the liquid adhesive product of 0.1 to 75 percent, EPA estimated a DBP use rate of 1.5 to 106,124 kg/site-year. Additionally, the ESD estimated the number of operating days as 50 to 365 days/year while NEI reporters indicated an average of 269 release days per year (U.S. EPA, 2019; OECD, 2015). EPA identified 166 entries in the 2017 and 2020 NEI databases for air releases from sites that were assumed to use adhesive/sealant or paint/coating products that contained DBP; however, the product type used between these two groups was uncertain and, due to reporting thresholds, this estimate may not represent all adhesive application sites (U.S. EPA, 2023a, 2019). EPA identified 1 entry in the TRI database for air releases from sites that were assumed to use adhesive/sealant or paint/coating products that contained DBP; however, the product type used between these two groups was uncertain and, due to reporting thresholds, this estimate may not represent all adhesive application sites (U.S. EPA, 2024a). Due to these uncertainties, EPA estimated the total number of application sites that use DBP-containing adhesives and sealants using a Monte Carlo model (see Appendix D.3 for details). The 50th to 95th percentile range of the number of sites was 94 to 793 based on the production volume and site throughput estimates.

3.7.3 Release Assessment

3.7.3.1 Environmental Release Points

EPA assigned release points based on the 2015 ESD on the Use of Adhesives (OECD, 2015) and based on NEI (2020), NEI (2017), TRI data (U.S. EPA, 2024e, 2023a, 2019). The ESD identified models to quantify releases from each release point for water and land releases. EPA expects releases to water, incineration, or landfill from equipment cleaning waste and releases to incineration or landfill from adhesive component container residue and trimming wastes. EPA expects releases to water, air, incineration, or landfill from process releases during adhesive application.

3.7.3.2 Environmental Release Assessment Results

Table 3-42 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES. Table 3-43 presents fugitive and stack air releases per year based on the TRI database along with the number of release days per year. Table 3-44 presents fugitive and stack air releases per year and per day based on 2020 NEI database along with the number of release days per year. Table 3-45 presents fugitive and stack air releases per year and per day based on 2017 NEI database along with the number of release days per year. EPA used

NEI data for air emissions data, so modeled air emissions are not presented. See Appendix D.3.2 for additional details on model equations, and different parameters used for Monte Carlo modeling. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases. The *Draft Application of Adhesives and Sealants OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP)* contains additional information about model equations and parameters and contains calculation results. The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)* contains additional information about identified air releases and their original sources, refer to Appendix F for a reference to these supplemental documents.

Table 3-42. Summary of Modeled Environmental Releases for Application of Adhesives and Sealants

<table>
<tr><th rowspan="2">Modeled Scenario</th><th rowspan="2">Environmental Media</th><th colspan="2">Annual Release (kg/site-year)</th><th colspan="2">Number of Release Days</th><th colspan="2">Daily Release (kg/site-day)</th></tr>
<tr><th>Central Tendency</th><th>High-End</th><th>Central Tendency</th><th>High-End</th><th>Central Tendency</th><th>High-End</th></tr>
<tr><td rowspan="3">99,157–2,140,323 kg/year production volume</td><td>Fugitive Air</td><td colspan="2">NEI/TRI data</td><td rowspan="3">232</td><td rowspan="3">325</td><td colspan="2">NEI/ TRI Data</td></tr>
<tr><td>Water, Incineration, or Landfill[a]</td><td>209</td><td>860</td><td>0.97</td><td>4.5</td></tr>
<tr><td>Incineration or Landfill[a]</td><td>291</td><td>1,357</td><td>1.4</td><td>7.1</td></tr>
<tr><td colspan="8">[a] When multiple environmental media are addressed together, releases may go all to one media, or be split between media depending on site-specific practices. Not enough data was provided to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.</td></tr>
</table>

Table 3-43. Summary of TRI Air Release Data for Application of Paints, Coatings, Adhesives and Sealants

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Heytex- USA	0	0	250	0	0

Table 3-44. Summary of NEI (2020) for Application of Paints, Coatings, Adhesives and Sealants

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Sikorsky Aircraft Corporation	N/A	9.8E−03	250	N/A	3.9E−05
Electric Boat Corp	0	36	250	0	0.14
FCA US LLC	N/A	67	250	N/A	0.27
Knud Nielsen (WAF)	64	N/A	250	0.25	N/A
Vulcraft Inc	N/A	0	250	N/A	0
George C Marshall Space Flight Center	N/A	118	250	N/A	0.47
Tiffin Motor Homes Inc	290	N/A	250	1.16	N/A
Anacapa Boatyard	0.79	N/A	260	3.0E−03	N/A
Applied Aerospace Str Corp	N/A	0	260	N/A	0
Marine Group Boat Works LLC	5.0	N/A	190	2.6E−02	N/A
Fellowes Inc	N/A	61	250	N/A	0.25
Britt Industries	N/A	1.0E−02	250	N/A	4.2E−05
Textron Aviation – Independence	5.7	N/A	200	2.8E−02	N/A
Talaria Co., LLC	7.7	N/A	250	3.1E−02	N/A
Safe Harbor New England Boatworks Inc.	1.5	N/A	250	6.1E−03	N/A
Gibson Guitar Custom Shop	N/A	13	250	N/A	5.0E−02
Crestwood Inc.	N/A	0	250	N/A	0
BAE Systems SDSR	1.0	N/A	250	4.2E−03	N/A
Ventura Harbor Boatyard Inc.	49	N/A	312	0.16	N/A
Ritz Craft Corp/Mifflinburg PLT	36	N/A	191	0.19	N/A
US Department of Energy Office of Science, Oak Ridge National Laboratory	N/A	0	250	N/A	0
Watco Transloading LLC	N/A	6.9	250	N/A	2.7E−02
Lockheed Martin Aeronautics Company	3.0	N/A	350	8.7E−03	N/A
Hearne Maintenance Facility	122	N/A	365	0.33	N/A
North American Lighting Inc.	N/A	5.4	250	N/A	2.2E−02
Hallmark Cards – Lawrence	15	N/A	364	4.2E−02	N/A
Trinity Industries Plant 19	N/A	0	250	N/A	0
Gibson USA	N/A	10	250	N/A	4.0E−02
USAF Shaw Air Force Base	N/A	0	250	N/A	0
Thermo King Corporation	N/A	0.78	250	N/A	3.1E−03

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
The Boeing Company St. Louis	1.22	N/A	250	4.9E−03	N/A
Vulcraft – Division of Nucor Corporation- Steel Products Manufacturing	3.0	N/A	250	1.2E−02	N/A
Progress Rail Service – Electric Fuels Corp	N/A	2.8	250	N/A	1.1E−02
Textron Aviation – West Campus	N/A	0	364	N/A	0
Textron Aviation – Pawnee Campus	0.91	N/A	312	2.9E−03	N/A
Fort Hood	9.1E−02	N/A	260	3.5E−04	N/A
Island Park Fabrication Plant	9.1E−02	0	111	8.2E−04	0
US Air Force Plant 4	18	N/A	250	7.1E−02	N/A
Embraer Aircraft Maint Services, Inc	N/A	1.9E−05	250	N/A	7.8E−08
Barber Cabinet Co Inc	N/A	59	250	N/A	0.24
Portsmouth Naval Shipyard – Kittery	N/A	0	250	N/A	0
Wastequip Manufacturing Co	N/A	0	250	N/A	0
Quality Painting & Metal Finishing Inc	N/A	0	250	N/A	0
Commercial Plastics Mora LLC	1.38	0	250	5.5E−03	0
HATCO	N/A	0	200	N/A	0
Raytheon Technologies	1.8E−02	N/A	250	7.3E−05	N/A
Electric Boat Corporation	0.66	N/A	250	2.6E−03	N/A
Chief Agri Industrial Products	1.8E−03	0	200	9.1E−06	0
Boeing Company St. Charles	N/A	3.2E−04	250	N/A	1.3E−06
Marvin Windows and Doors	N/A	0	250	N/A	0
Modern Design LLC	N/A	0	250	N/A	0
Progress Rail Service – DeCoursey Car Shop	N/A	0	250	N/A	0
Caterpillar INC	0.36	N/A	250	1.5E−03	N/A
Kurz Transfer Products, LP	0	126	364	0	0.35
Northrop Grumman Systems Corp. – BWI	0	5.6	260	0	2.1E−02
Bernhardt Furniture Company – Plants 3&7	0	0.16	250	0	6.5E−04
Fleet Readiness Center East	0.57	60	364	1.6E−03	0.16

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Kirtland Air Force Base	7.3E−02	N/A	364	2.0E−04	N/A
Maintenance Engineering Center	0.45	0	365	1.2E−03	0
Textron Aviation – East Campus	1.1	N/A	300	3.6E−03	N/A
3M Hutchinson	N/A	0	250	N/A	0
Swaim, Inc.	N/A	4.4E−06	250	N/A	1.7E−08
Hickory Chair, LLC	N/A	0	250	N/A	0
Ethan Allen Inc (Orleans Div)	N/A	0	250	N/A	0
Woodgrain Millwork Inc. – Fruitland	N/A	0	250	N/A	0
Huntington Ingalls Inc, Ingalls Shipbuilding	80	N/A	250	0.32	N/A
Eudys Cabinet Manufacturing, Inc.	62	0	250	0.25	0
Tektronix, Inc.	1.6	N/A	250	6.5E−03	N/A
Marine Corps Air Station – Cherry Point	6.3E−03	33	364	1.7E−05	9.1E−02
PLASTIC FILM PLANT	1.81	0	365	5.0E−03	0
Spirit AeroSystems – Wichita	18	N/A	364	5.0E−02	N/A
Lockheed Martin Aeronautics Company	N/A	4.5	312	N/A	1.4E−02
Cobham Advanced Electronics Solutions Inc.	8.7E−05	N/A	270	3.2E−07	N/A
Nashville Custom Woodwork, Inc.	N/A	2.7	250	N/A	1.1E−02
Apex Engineering – Wichita (W 2nd)	N/A	18	260	N/A	6.7E−02
Lewistown Cabinet Ctr/Milroy	N/A	3.0E−09	232	N/A	1.3E−11
University of Iowa	N/A	0	250	N/A	0
United Airlines IAH Airport	0.64	N/A	260	2.4E−03	N/A
Cabinotch, Inc.	N/A	64	250	N/A	0.25
Alstom Power Inc	N/A	60	250	N/A	0.24
Central Sandblasting Company	N/A	0	250	N/A	0
SHM LMC LLC	9.2	N/A	364	2.5E−02	N/A
Nautical Structures Industries, Inc.	N/A	9.3	312	N/A	3.0E−02
Amcor Pharmaceutical Packaging USA Inc	N/A	0	250	N/A	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
HME Inc.	N/A	0	280	N/A	0
Marine Corps Logistics Base	1409	N/A	365	3.86	N/A
Schenck Process – Sabetha	19	N/A	258	7.4E−02	N/A
P C Auto Body	0.79	N/A	260	3.0E−03	N/A
Freight Car America	N/A	0	250	N/A	0
The New York Blower Company	N/A	0	250	N/A	0
Eminence Speaker LLC	46	N/A	250	0.18	N/A
C & L Aerospace Holdings, LLC	N/A	0.72	250	N/A	2.9E−03
Teknicote	1.9	N/A	250	7.4E−03	N/A
The Boeing Company	0.38	N/A	365	1.1E−03	N/A
Premier Marine LLC	N/A	0	250	N/A	0
Curry Supply Co/Hollidaysburg	N/A	0	365	N/A	0
Phillips Diversified Manufacturing (PDM) Inc	N/A	266	250	N/A	1.1
Kalitta Air, LLC	0.68	N/A	250	2.7E−03	N/A
Davis Tool, Inc.	N/A	0	250	N/A	0

Table 3-45. Summary of NEI (2017) for Application of Paints, Coatings, Adhesives and Sealants

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Ventura Harbor Marina & Yacht Yard	0.77	N/A	250	3.1E−03	N/A
Bellport Anacapa Marine Services	58	N/A	40	1.44	N/A
Naval Base Ventura County	1.1	N/A	250	4.2E−03	N/A
Eagle Wings Industries Inc	N/A	1.55	250	N/A	6.2E−03
Electronic Data Systems North Island	5.96	N/A	250	2.4E−02	N/A
FIC America Corp	N/A	0	250	N/A	0
CE Niehoff & Co	N/A	13	250	N/A	5.2E−02
U.S. Postal Service- Mail Facility	6.9	N/A	250	2.8E−02	N/A
Us Airways Maintenance Base/Pgh	N/A	0	250	N/A	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
El Paso Division	N/A	0	250	N/A	0
New England Boatworks Inc.	0.91	N/A	250	3.6E−03	N/A
American Shipyard LLC.	8.3	N/A	250	3.3E−02	N/A
Knapheide Manufacturing Co	N/A	6.6	250	N/A	2.6E−02
Bae Systems San Diego Ship Repair Inc	1.8	N/A	250	7.4E−03	N/A
Bill Stasek Chevrolet Inc	N/A	1.6	250	N/A	6.5E−03
GBW Railcar Services LLC	N/A	34	250	N/A	0.14
Lockheed Martin Aeronautics Company Palmdale	1.2	N/A	350	3.5E−03	N/A
West Refinery	2.7	N/A	250	1.1E−02	N/A
TTX Company	N/A	7.3E−03	208	N/A	3.5E−05
American Ntn Bearing Mfg Corp	N/A	0.16	250	N/A	6.6E−04
Stripmasters Of Illinois	N/A	3.5	250	N/A	1.4E−02
Modern Welding Company Of Kentucky Inc – Elizabethtown	N/A	0	250	N/A	0
Union Pacific Railroad Co Desoto Car Shop	N/A	0	250	N/A	0
DFW Maintenance Facility	0.36	N/A	365	9.9E−04	N/A
United Parcel Service, Worldport	2.2	7.6E−03	250	8.9E−03	3.0E−05
Progress Rail Raceland Corp	N/A	0	250	N/A	0
Institutional Casework, Inc	N/A	0	250	N/A	0
Wastequip Manufacturing Co LLC	N/A	0.67	250	N/A	2.7E−03
Litho Technical Services	N/A	18	250	N/A	7.1E−02
Delta Air Lines Inc – Mpls/Saint Paul	N/A	58	250	N/A	0.23
Construction Materials/CMI Coatings Group Dba Industrial Painting Specialists	0.15	13	250	5.9E−04	5.1E−02
Crystal Cabinet Works Inc	0.11	106	250	4.3E−04	0.43
3m – Alexandria	N/A	0	250	N/A	0
Johnston Tombigbee Furniture Company, Co	N/A	0	250	N/A	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Knu LLC	N/A	0	250	N/A	0
Structural Steel Services Inc, Plants 1	N/A	0	250	N/A	0
Harden Furniture Inc	N/A	0	250	N/A	0
General Motors LLC Wentzville Center	N/A	0	250	N/A	0
Ford Motor Co	N/A	10	250	N/A	4.2E−02
Commercial Property LLC – Carolina Heritage Cabinetry Plt. 2	N/A	41	250	N/A	0.16
Caldwell Tanks	N/A	38	250	N/A	0.15
L & J G Stickley Inc	14	N/A	250	5.5E−02	N/A
Ethan Allen Operations, Inc. – Pine Valley Division	N/A	0	250	N/A	0
Pompanoosuc Mills Corp	N/A	0	250	N/A	0
Hamilton Square Lenoir Casegoods Plant	N/A	0	250	N/A	0
Panels, Services & Components, Inc.	22	N/A	208	0.11	N/A
Fort Drum – U.S. Military	N/A	617	250	N/A	2.5
Haeco Airframe Services, LLC	7.2	0	364	2.0E−02	0
May-Craft Fiberglass Products, Inc.	N/A	13	364	N/A	3.5E−02
Structural Coatings Inc. – Clayton	N/A	0	312	N/A	0
Rockwell Collins, Inc.	N/A	0	365	N/A	0
Manchester Wood Inc	N/A	0	250	N/A	0
Wabash National Corp	N/A	0	250	N/A	0
Lexington Furniture Industries – Plant No. 15	N/A	38	250	N/A	0.15
Spear USA	N/A	2.8E−02	250	N/A	1.1E−04
Knapheide Truck Equipment Co	N/A	199	250	N/A	0.80
Piedmont Composites and Tooling, LLC	N/A	0	200	N/A	0
UPM Raflatac Inc Dixon Il	N/A	0	250	N/A	0
Phills Custom Cabinets	N/A	3.6E−04	250	N/A	1.5E−06
Kellex Corporation, Inc. – Morganton Facility	N/A	0	250	N/A	0
CRP LMC Prop Co., LLC	3.1	N/A	364	8.5E−03	N/A

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Ornamental Products, LLC	N/A	0	250	N/A	0
Leggett & Platt, Inc. – Metal Bed Rail	2233	N/A	260	8.59	N/A
Century Furniture – Plant No. 2	N/A	0	250	N/A	0
Mickelson Body Shop	N/A	32	250	N/A	0.13
Premier Marine Inc	N/A	0	250	N/A	0

3.7.4 Occupational Exposure Assessment

3.7.4.1 Worker Activities

During the use of adhesives and sealants containing DBP, worker inhalation exposures to DBP may occur while unloading, applying, and mixing any liquid component of the adhesive or sealant, such as a liquid catalyst or 1-part adhesive. Worker dermal exposures to DBP in adhesives and sealants may occur while unloading, mixing, applying, curing or drying, container cleaning, and application equipment cleaning (OECD, 2015). EPA did not identify information on engineering controls or worker PPE used at DBP-containing adhesive and sealant sites.

ONUs include supervisors, managers, and other employees that work in the application area but do not directly contact adhesives or sealants or handle or apply products. ONUs are potentially exposed via inhalation to vapors while in the working area.

3.7.4.2 Occupational Inhalation Exposure Results

EPA identified 19 monitoring samples in NIOSH's HHE database (NIOSH, 1977). The source received a rating of medium from EPA's systematic review process. Six of the samples were PBZ samples, and the remaining 13 samples were area samples taken at various locations around an acrylic furniture manufacturing site. The site uses 2-part adhesives where the part B component is 96.5 percent DBP. Two of the area samples recorded values at the limit of detection, and the remaining 17 samples were below the limit of detection. All samples were collected on AA cellulose membrane filters with 0.8µ average pore size and a pump flow rate of 1 LPM. The detection limit was 0.01 mg/m^3 by gas chromatography. With all samples at or below the LOD, EPA assessed inhalation exposures as a range from 0 to the LOD. EPA estimated the high-end exposure as equal to the LOD and the central tendency as the midpoint (*i.e.*, half the LOD).

In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. EPA assessed the exposure frequency as 250 days/year for both high-end and central tendency exposures based on the expected operating days for the OES and accounting for off days for workers.

Table 3-46 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during the use of adhesives and sealants. Appendix A describes the approach for estimating AD, IADD, and ADD. The *Draft Occupational Inhalation Exposure Monitoring Results for*

Dibutyl Phthalate (DBP) contains further information on the identified inhalation exposure data and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-46. Summary of Estimated Worker Inhalation Exposures for Application of Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	0.10
	Acute Dose (AD) (mg/kg-day)	6.3E−03	1.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−03	9.2E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.0E−03	8.6E−03
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	0.10
	Acute Dose (AD) (mg/kg-day)	6.9E−03	1.4E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	5.1E−03	1.0E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.4E−03	9.5E−03
ONU	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	5.0E−02
	Acute Dose (AD) (mg/kg-day)	6.3E−03	6.3E−03
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−03	4.6E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.0E−03	4.3E−03

[a] EPA used monitoring data for adhesive application as described by 19 monitoring samples in NIOSH's HHE database (NIOSH, 1977), which received a rating of medium from EPA's systematic review process. The Agency estimated the high-end exposure as equal to the LOD and the central tendency as the midpoint (*i.e.*, half the LOD).

3.7.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-47 are explained in Appendix A. Because there may be mist deposited on surfaces from this OES, dermal exposures to ONUs from contact with mist on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper PPE or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-47 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-47. Summary of Estimated Worker Dermal Exposures for Application of Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	100	201
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.92	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.80	1.7
Female of Reproductive Age	Dose Rate (APDR, mg/day)	84	167
	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.85	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.73	1.6
ONU	8-hour TWA Exposure Concentration (mg/m^3)	100	100
	Acute (AD, mg/kg-day)	1.3	1.3
	Intermediate (IADD, mg/kg-day)	0.92	0.92
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.80	0.86

Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).

3.7.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-48. Summary of Estimated Worker Aggregate Exposures for Application of Adhesives and Sealants

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.92	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.80	1.7
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.85	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.74	1.6
ONU	Acute (AD, mg/kg-day)	1.3	1.3
	Intermediate (IADD, mg/kg-day)	0.92	0.92
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.80	0.86
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.8 Application of Paints and Coatings

3.8.1 Process Description

EPA identified the use of DBP in paint and coating products for industrial and commercial use, including floor coatings, polyvinyl acetate coatings, lacquers, varnishes, and paints and coatings used in the building and construction industry (U.S. EPA, 2020a). Liquid paint and coating products containing DBP may arrive at end use sites in containers ranging in size from 5 to 20 gallons and at concentrations ranging from 0.1 to 10 percent DBP (see Appendix E for EPA identified DBP-containing products for this OES). The size of the container is an input to the Monte Carlo simulation to estimate releases but is not used to calculate occupational exposures for DBP. For these products, the application site receives the final formulation as a single-component paint/coating product.

The application site directly transfers the liquid product to the application equipment to apply the coating to the substrate (OECD, 2015). The application procedure depends on the type of paint or coating formulation and the type of substrate. Typically, the formulation is loaded into the application reservoir or apparatus and applied to the substrate via brush, spray, roll, dip, curtain, or syringe or bead application (OECD, 2015). Application may be manual or automated. Manual spray equipment includes air (*e.g.*, low volume/high pressure), air-assisted, and airless spray systems (OECD, 2011a, 2009c; U.S. EPA, 2004d). End use sites may utilize spray booth capture technologies when performing spray applications (OECD, 2011a). DBP will remain in the dried/cured coating as an additive following application to the substrate. The drying/curing process may be promoted through the use of heat or radiation (radiation can include ultraviolet (UV) and electron beam radiation) (OECD, 2010).

EPA assumes that use sites perform coating activities using spray application methods, as this is expected to generate the highest release and exposure estimates. Applications may occur over the course of a worker's 8-hour workday at a given site and may include multiple coats and time for drying or curing (OECD, 2011b). Figure 3-9 provides an illustration of the spray application of paints and coatings (OECD, 2011a, b, 2009c; U.S. EPA, 2004d).

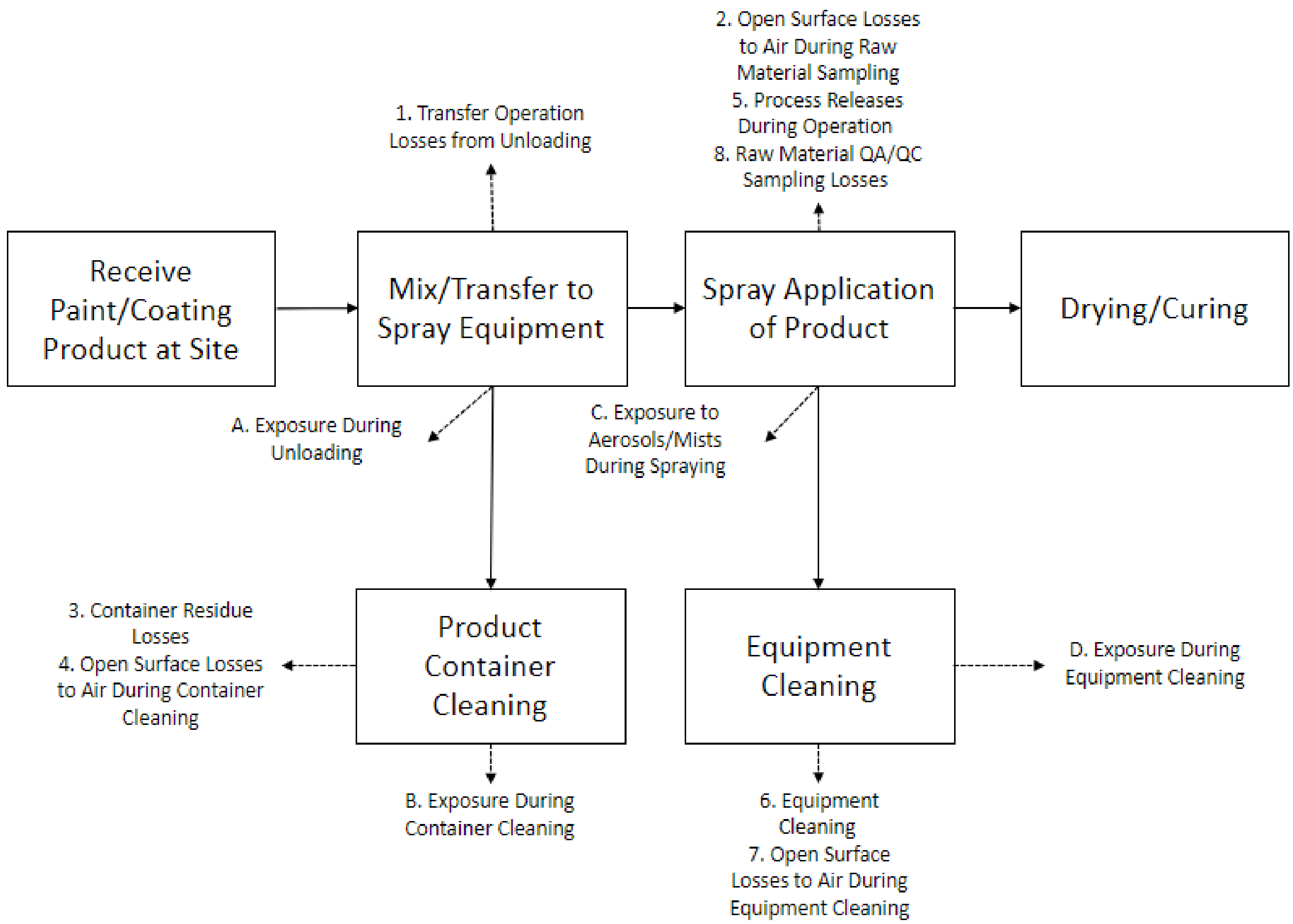


Figure 3-9. Application of Paints and Coatings Flow Diagram

3.8.2 Facility Estimates

EPA estimated the total DBP production volume for paint and coating products using a uniform distribution with a lower-bound of 99,157 kg/year and an upper-bound of 2,140,323 kg/year. This range is based on DBP CDR data of site production volumes, national aggregate production volumes, and percentages of the production volumes going to various industrial sectors (U.S. EPA, 2020a).

There were two reporters that reported to CDR for use of DBP in adhesive/sealant or paint/coating products: G.J. Chemical Co, Inc. in Somerset, NJ, who reported a volume of 139,618 lb and MAK Chemicals in Clifton, NJ, who reported a use volume of 105,884 lb of DBP. This equates to a total known use volume of 245,502 lb of DBP; however, there is still a large portion of the aggregate PV range for DBP that is not attached to a known use. A breakdown of the known production volume information is provided in Table_Apx D-7.

Due to uncertainty in the expected use of DBP, EPA assumes that the remaining PV with unknown use is split between the use of adhesives and sealants and paint and coating products. Subtracting the PV with known uses that are not associated with adhesives/sealants/paints/coatings from the aggregate national PV range equates to a range of 99,157 to 2,140,323 kg for this OES (see Section D.4.3). EPA used the range of production volumes as an input to the Monte Carlo modeling described in Appendix D to estimate releases. The production volume range is not used to calculate occupational exposures for DBP.

EPA did not identify site- or chemical-specific paint and coating use operating data (*e.g.*, facility use rates). EPA based the facility use rate on the 2011 ESD on Radiation Curable Coatings, Inks and Adhesives, the 2011 ESD on Coating Application via Spray-Painting in the Automotive Finishing Industry, the 2004 GS on Spray Coatings in the Furniture Industry, and the European Council of the Paint, Printing Ink, and Artist's Colours Industry (CEPE) *SpERC Factsheet for Industrial Application of Coatings and Inks by Spraying*. The ESDs, GS, and SpERC estimated coating use rates of 946 to 446,600 kg/site-year. Based on a DBP concentration in liquid paints and coatings of 0.1 to 10 percent, EPA estimated a DBP use rate of 0.95 to 44,660 kg/site-year. Additionally, the ESDs, GS, and SpERC estimated the number of operating days as 225 to 300 days/year with 8 hour/day operations, while NEI reporters indicated an average of 269 release days per year (ESIG, 2020a; U.S. EPA, 2019; OECD, 2011a, b; U.S. EPA, 2004c). EPA identified 166 entries in the 2017 and 2020 NEI databases for air releases from sites that were assumed to use adhesive/sealant or paint/coating products that contained DBP; however, the product type used between these two groups was uncertain (U.S. EPA, 2019). EPA identified 1 entry in the TRI database for air releases from sites that were assumed to use adhesive/sealant or paint/coating products that contained DBP; however, the product type used between these two groups was uncertain and, due to reporting thresholds, this estimate may not represent all adhesive application sites (U.S. EPA, 2024a). Due to this uncertainty, EPA estimated the total number of application sites that use DBP-containing paints and coatings using a Monte Carlo model (see Appendix D.4 for details). The 50th to 95th percentile range of the number of sites was 219 to 2,660.

3.8.3 Release Assessment

3.8.3.1 Environmental Release Points

EPA assigned release points based on the 2011 ESD on Radiation Curable Coatings, Inks and Adhesives (OECD, 2011b) and NEI (2020) and NEI (2017) data (U.S. EPA, 2023a, 2019). The ESD identified models to quantify releases from each release point for water, incineration, and landfill and NEI data for air releases. EPA expects stack air releases from process releases during operation and fugitive air releases from transfer operations, raw material sampling, container cleaning, and equipment cleaning. EPA expects water, incineration, or landfill releases from container residue losses and sampling. Releases to incineration or landfill are expected from equipment cleaning and process releases in addition to fugitive air, water, incineration, or landfill releases from process releases during operation.

EPA modeled two scenarios, one where application sites use overspray control technologies and one where no controls are used. Sites may utilize overspray control technology to prevent additional air releases during spray application. If a site uses overspray control technology, EPA expects stack air releases of approximately 10 percent of process related operational losses. EPA expects the site to release the remaining 90 percent of operational losses to water, landfill, or incineration (OECD, 2011b). If the site does not use control technology, EPA expects the site to release all process related operational losses to fugitive air, water, incineration, or landfill in unknown percentages.

3.8.3.2 Environmental Release Assessment Results

Table 3-49 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES. Table 3-50 presents fugitive and stack air releases per year based on the TRI database along with the number of release days per year. Table 3-51 presents fugitive and stack air releases per year and per day based on 2020 NEI database along with the number of release days per year. Table 3-52 presents fugitive and stack air releases per year and per day based on 2017 NEI database along with the number of release days per year. See Appendix D.4.2 for additional details on model equations, and different parameters used for Monte Carlo modeling. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively. The *Draft Application of Paints and Coatings OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP)* contains additional information about model equations and parameters and contains calculation results. The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)* contains additional information about identified air releases and their original sources, refer to Appendix F for a reference to these supplemental documents.

Table 3-49. Summary of Modeled Environmental Releases for Application of Paints and Coatings

Modeled Scenario	Environmental Media	Annual Release (kg/site-year)		Number of Release Days		Daily Release[b] (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
99,157–2,140,323 kg/year production volume (No Spray Control)	Fugitive Air	NEI/TRI data		257	287	NEI/ TRI Data	
	Stack Air	NEI/TRI data				NEI/TRI data	
	Water, Incineration, or Landfill[a]	72	206			0.28	0.80
	Incineration or Landfill[a]	92	368			0.36	1.4
	Unknown (air, water, incineration, or landfill)[a]	1,957	8,655			7.6	34
99,157–2,140,323 kg/year production volume (Spray Control)	Fugitive Air	NEI/TRI data		257	287	NEI/TRI data	
	Stack Air	NEI/TRI data				NEI/TRI data	
	Water, Incineration, or Landfill[a]	72	206			0.28	0.80
	Incineration or Landfill[a]	1,858	8,170			7.2	32

[a] When multiple environmental media are addressed together, releases may go all to one media, or be split between media depending on site-specific practices. Not enough data was provided to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table 3-50. Summary of TRI Air Release Data for Application of Paints, Coatings, Adhesives and Sealants

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Heytex- USA	0	0	250	0	0

Table 3-51. Summary of NEI (2020) Air Releases for Application of Paints, Coatings, Adhesives and Sealants

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Sikorsky Aircraft Corporation	N/A	9.8E−03	250	N/A	3.9E−05
Electric Boat Corp	0	36	250	0	0.14
FCA US LLC	N/A	67	250	N/A	0.27
Knud Nielsen (WAF)	64	N/A	250	0.25	N/A
Vulcraft Inc	N/A	0	250	N/A	0
George C Marshall Space Flight Center	N/A	118	250	N/A	0.47
Tiffin Motor Homes Inc	290	N/A	250	1.16	N/A
Anacapa Boatyard	0.79	N/A	260	3.0E−03	N/A
Applied Aerospace Str Corp	N/A	0	260	N/A	0
Marine Group Boat Works LLC	5.0	N/A	190	2.6E−02	N/A
Fellowes Inc	N/A	61	250	N/A	0.25
Britt Industries	N/A	1.0E−02	250	N/A	4.2E−05
Textron Aviation – Independence	5.7	N/A	200	2.8E−02	N/A
Talaria Co., LLC	7.7	N/A	250	3.1E−02	N/A
Safe Harbor New England Boatworks Inc.	1.5	N/A	250	6.1E−03	N/A
Gibson Guitar Custom Shop	N/A	13	250	N/A	5.0E−02
Crestwood Inc.	N/A	0	250	N/A	0
BAE Systems SDSR	1.0	N/A	250	4.2E−03	N/A
Ventura Harbor Boatyard Inc.	49	N/A	312	0.16	N/A
Ritz Craft Corp/Mifflinburg PLT	36	N/A	191	0.19	N/A
US Department of Energy Office of Science, Oak Ridge National Laboratory	N/A	0	250	N/A	0
Watco Transloading LLC	N/A	6.9	250	N/A	2.7E−02
Lockheed Martin Aeronautics Company	3.0	N/A	350	8.7E−03	N/A
Hearne Maintenance Facility	122	N/A	365	0.33	N/A
North American Lighting Inc.	N/A	5.4	250	N/A	2.2E−02
Hallmark Cards – Lawrence	15	N/A	364	4.2E−02	N/A
Trinity Industries Plant 19	N/A	0	250	N/A	0
Gibson USA	N/A	10	250	N/A	4.0E−02
USAF Shaw Air Force Base	N/A	0	250	N/A	0
Thermo King Corporation	N/A	0.78	250	N/A	3.1E−03
The Boeing Company St. Louis	1.2	N/A	250	4.9E−03	N/A

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Vulcraft – Division of Nucor Corporation- Steel Products Manufacturing	3.0	N/A	250	1.2E−02	N/A
Progress Rail Service – Electric Fuels Corp	N/A	2.8	250	N/A	1.1E−02
Textron Aviation – West Campus	N/A	0	364	N/A	0
Textron Aviation – Pawnee Campus	0.91	N/A	312	2.9E−03	N/A
Fort Hood	9.1E−02	N/A	260	3.5E−04	N/A
Island Park Fabrication Plant	9.1E−02	0	111	8.2E−04	0
US Air Force Plant 4	18	N/A	250	7.1E−02	N/A
Embraer Aircraft Maint Services, Inc	N/A	1.9E−05	250	N/A	7.8E−08
Barber Cabinet Co Inc	N/A	59	250	N/A	0.24
Portsmouth Naval Shipyard – Kittery	N/A	0	250	N/A	0
Wastequip Manufacturing Co	N/A	0	250	N/A	0
Quality Painting & Metal Finishing Inc	N/A	0	250	N/A	0
Commercial Plastics Mora LLC	1.38	0	250	5.5E−03	0
HATCO	N/A	0	200	N/A	0
Raytheon Technologies	1.8E−02	N/A	250	7.3E−05	N/A
Electric Boat Corporation	0.66	N/A	250	2.6E−03	N/A
Chief Agri Industrial Products	1.8E−03	0	200	9.1E−06	0
Boeing Company St. Charles	N/A	3.2E−04	250	N/A	1.3E−06
Marvin Windows and Doors	N/A	0	250	N/A	0
Modern Design LLC	N/A	0	250	N/A	0
Progress Rail Service – DeCoursey Car Shop	N/A	0	250	N/A	0
Caterpillar INC	0.36	N/A	250	1.5E−03	N/A
Kurz Transfer Products, LP	0	126	364	0	0.35
Northrop Grumman Systems Corp. – BWI	0	5.6	260	0	2.1E−02
Bernhardt Furniture Company – Plants 3&7	0	0.16	250	0	6.5E−04
Fleet Readiness Center East	0.57	60	364	1.6E−03	0.16
Kirtland Air Force Base	7.3E−02	N/A	364	2.0E−04	N/A
Maintenance Engineering Center	0.45	0	365	1.2E−03	0
Textron Aviation – East Campus	1.1	N/A	300	3.6E−03	N/A
3M Hutchinson	N/A	0	250	N/A	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Swaim, Inc.	N/A	4.4E−06	250	N/A	1.7E−08
Hickory Chair, LLC	N/A	0	250	N/A	0
Ethan Allen Inc (Orleans Div)	N/A	0	250	N/A	0
Woodgrain Millwork Inc. – Fruitland	N/A	0	250	N/A	0
Huntington Ingalls Inc, Ingalls Shipbuil	80	N/A	250	0.32	N/A
Eudys Cabinet Manufacturing, Inc.	62	0	250	0.25	0
Tektronix, Inc.	1.6	N/A	250	6.5E−03	N/A
Marine Corps Air Station – Cherry Point	6.3E−03	33	364	1.7E−05	9.1E−02
Plastic Film Plant	1.8	0	365	5.0E−03	0
Spirit AeroSystems – Wichita	18	N/A	364	5.0E−02	N/A
Lockheed Martin Aeronautics Company	N/A	4.5	312	N/A	1.4E−02
Cobham Advanced Electronics Solutions Inc.	8.7E−05	N/A	270	3.2E−07	N/A
Nashville Custom Woodwork, Inc.	N/A	2.7	250	N/A	1.1E−02
Apex Engineering – Wichita (W 2nd)	N/A	18	260	N/A	6.7E−02
Lewistown Cabinet Ctr/Milroy	N/A	3.0E−09	232	N/A	1.3E−11
University of Iowa	N/A	0	250	N/A	0
United Airlines IAH Airport	0.64	N/A	260	2.4E−03	N/A
Cabinotch, Inc.	N/A	64	250	N/A	0.25
Alstom Power Inc	N/A	60	250	N/A	0.24
Central Sandblasting Company	N/A	0	250	N/A	0
SHM LMC LLC	9.2	N/A	364	2.5E−02	N/A
Nautical Structures Industries, Inc.	N/A	9.3	312	N/A	3.0E−02
Amcor Pharmaceutical Packaging USA Inc	N/A	0	250	N/A	0
HME Inc.	N/A	0	280	N/A	0
Marine Corps Logistics Base	1409	N/A	365	3.9	N/A
Schenck Process – Sabetha	19	N/A	258	7.4E−02	N/A
P C Auto Body	0.79	N/A	260	3.0E−03	N/A
Freight Car America	N/A	0	250	N/A	0
The New York Blower Company	N/A	0	250	N/A	0
Eminence Speaker LLC	46	N/A	250	0.18	N/A

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
C & L Aerospace Holdings, LLC	N/A	0.72	250	N/A	2.9E−03
Teknicote	1.9	N/A	250	7.4E−03	N/A
The Boeing Company	0.38	N/A	365	1.1E−03	N/A
Premier Marine LLC	N/A	0	250	N/A	0
Curry Supply Co/Hollidaysburg	N/A	0	365	N/A	0
Phillips Diversified Manufacturing (PDM) Inc	N/A	266	250	N/A	1.06
Kalitta Air, LLC	0.68	N/A	250	2.7E−03	N/A
Davis Tool, Inc.	N/A	0	250	N/A	0

Table 3-52. Summary of NEI (2017) for Application of Paints, Coatings, Adhesives and Sealants

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Ventura Harbor Marina & Yacht Yard	0.77	N/A	250	3.1E−03	N/A
Bellport Anacapa Marine Services	58	N/A	40	1.4	N/A
Naval Base Ventura County	1.1	N/A	250	4.2E−03	N/A
Eagle Wings Industries Inc	N/A	1.55	250	N/A	6.2E−03
Electronic Data Systems North Island	6.0	N/A	250	2.4E−02	N/A
FIC America Corp	N/A	0	250	N/A	0
CE Niehoff & Co	N/A	13	250	N/A	5.2E−02
U.S. Postal Service- Mail Facility	6.9	N/A	250	2.8E−02	N/A
Us Airways Maintenance Base/Pgh	N/A	0	250	N/A	0
EL PASO DIVISION	N/A	0	250	N/A	0
New England Boatworks Inc.	0.91	N/A	250	3.6E−03	N/A
American Shipyard LLC.	8.3	N/A	250	3.3E−02	N/A
Knapheide Manufacturing Co	N/A	6.6	250	N/A	2.6E−02
Bae Systems San Diego Ship Repair Inc	1.8	N/A	250	7.4E−03	N/A
Bill Stasek Chevrolet Inc	N/A	1.6	250	N/A	6.5E−03
GBW Railcar Services LLC	N/A	34	250	N/A	0.14

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Lockheed Martin Aeronautics Company Palmdale	1.2	N/A	350	3.5E−03	N/A
West Refinery	2.7	N/A	250	1.1E−02	N/A
TTX Company	N/A	7.3E−03	208	N/A	3.5E−05
American NTN Bearing Mfg Corp	N/A	0.16	250	N/A	6.6E−04
Stripmasters of Illinois	N/A	3.5	250	N/A	1.4E−02
Modern Welding Company of Kentucky Inc – Elizabethtown	N/A	0	250	N/A	0
Union Pacific Railroad Co Desoto Car Shop	N/A	0	250	N/A	0
DFW Maintenance Facility	0.36	N/A	365	9.9E−04	N/A
United Parcel Service, WorldPort	2.2	7.6E−03	250	8.9E−03	3.0E−05
Progress Rail Raceland Corp	N/A	0	250	N/A	0
Institutional Casework, Inc	N/A	0	250	N/A	0
Wastequip Manufacturing Co LLC	N/A	0.67	250	N/A	2.7E−03
Litho Technical Services	N/A	18	250	N/A	7.1E−02
Delta Air Lines Inc – Mpls/Saint Paul	N/A	58	250	N/A	0.23
Construction Materials/CMI Coatings Group dba Industrial Painting Specialists	0.15	13	250	5.9E−04	5.1E−02
Crystal Cabinet Works Inc	0.11	106	250	4.3E−04	0.43
3M – Alexandria	N/A	0	250	N/A	0
Johnston Tombigbee Furniture Company, Co	N/A	0	250	N/A	0
Knu LLC	N/A	0	250	N/A	0
Structural Steel Services Inc, Plants 1	N/A	0	250	N/A	0
Harden Furniture Inc	N/A	0	250	N/A	0
General Motors LLC Wentzville Center	N/A	0	250	N/A	0
Ford Motor Co	N/A	10	250	N/A	4.2E−02
Commercial Property LLC – Carolina Heritage Cabinetry Plt. 2	N/A	41	250	N/A	0.16
Caldwell Tanks	N/A	38	250	N/A	0.15

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
L & J G Stickley Inc	14	N/A	250	5.5E−02	N/A
Ethan Allen Operations, Inc. – Pine Valley Division	N/A	0	250	N/A	0
Pompanoosuc Mills Corp	N/A	0	250	N/A	0
Hamilton Square Lenoir Casegoods Plant	N/A	0	250	N/A	0
Panels, Services & Components, Inc.	22	N/A	208	0.11	N/A
Fort Drum – US Military	N/A	617	250	N/A	2.47
HAECO Airframe Services, LLC	7.2	0	364	2.0E−02	0
May-Craft Fiberglass Products, Inc.	N/A	13	364	N/A	3.5E−02
Structural Coatings Inc. – Clayton	N/A	0	312	N/A	0
Rockwell Collins, Inc.	N/A	0	365	N/A	0
Manchester Wood Inc	N/A	0	250	N/A	0
Wabash National Corp	N/A	0	250	N/A	0
Lexington Furniture Industries – Plant No. 15	N/A	38	250	N/A	0.15
SPEAR USA	N/A	2.8E−02	250	N/A	1.1E−04
Knapheide Truck Equipment Co	N/A	199	250	N/A	0.80
Piedmont Composites and Tooling, LLC	N/A	0	200	N/A	0
UPM Raflatac Inc Dixon IL	N/A	0	250	N/A	0
Phills Custom Cabinets	N/A	3.6E−04	250	N/A	1.5E−06
Kellex Corporation, Inc. – Morganton Facility	N/A	0	250	N/A	0
CRP LMC PROP CO., LLC	3.1	N/A	364	8.5E−03	N/A
Ornamental Products, LLC	N/A	0	250	N/A	0
Leggett & Platt, Inc. – Metal Bed Rail	2233	N/A	260	8.59	N/A
Century Furniture – Plant No. 2	N/A	0	250	N/A	0
Mickelson Body Shop	N/A	32	250	N/A	0.13
Premier Marine Inc	N/A	0	250	N/A	0

3.8.4 Occupational Exposure Assessment

3.8.4.1 Worker Activities

During the use of DBP-containing paints and coatings, workers are potentially exposed to DBP mist from overspray inhalation during spray coating. Workers may be exposed via inhalation of vapors or dermal contact to liquids containing DBP during product unloading into application equipment, brush and trowel applications, raw material sampling, and container and equipment cleaning (OECD, 2011b). EPA did not find information on the extent to which engineering controls and worker PPE are used at facilities that use DBP-containing paints and coatings.

For this OES, ONUs would include supervisors, managers, and other employees that do not directly handle paint or coating equipment but may be present in the application area. ONUs are potentially exposed through the inhalation of mist or vapor and dermal contact with surfaces where mist has been deposited.

3.8.4.2 Occupational Inhalation Exposure Results

EPA identified two full-shift PBZ monitoring samples in OSHA's CEHD from two different inspections one from 2011 of a fabric coating mill and one from a janitorial services company (OSHA, 2019). The OSHA CEHD database received a rating of high from EPA's systematic review process. The Agency additionally found 12 8-hour TWA monitoring samples during systematic review completed by Rohm and Haas Co. (Rohm and Haas, 1990). The study received a rating of low from EPA's systematic review process. With a total of 14 data points, EPA characterized the data by taking the 95th percentile and the 50th percentile of the combined dataset to represent the high-end and central tendency. There was no ONU-specific exposure data and EPA assumed that worker central tendency exposure is representative of ONU exposure. Therefore, worker central tendency exposure values from spray application were assumed representative of ONU inhalation exposure to the same.

Table 3-53 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP from unloading and mixing the solid DBP-containing component of a paint and coating and the spray application of liquid paints and coatings. The high-end exposures use 250 days per year as the exposure frequency since the 95th percentile of operating days in the release assessment exceeded 250 days per year, which is the expected maximum for working days. The central tendency exposures use 232 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix A describes the approach for estimating AD, IADD, and ADD. The dataset is expected to characterize all potential exposure routes, including any dust, mist, and vapor exposures. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-53. Summary of Estimated Worker Inhalation Exposures for Application of Paints and Coatings

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.83	5.2
	Acute Dose (AD) (mg/kg-day)	0.10	0.66
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	7.6E−02	0.48
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	7.1E−02	0.45

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m³)	0.83	5.2
	Acute Dose (AD) (mg/kg-day)	0.11	0.72
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	8.4E−02	0.53
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	7.8E−02	0.50
ONU	8-hour TWA Exposure Concentration (mg/m³)	0.83	0.83
	Acute Dose (AD) (mg/kg-day)	0.10	0.10
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	7.6E−02	7.6E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	7.1E−02	7.1E−02

[a] EPA identified two full-shift PBZ monitoring samples in OSHA's Chemical Exposure Health Data database (OSHA, 2019). The study received a rating of high from EPA's systematic review process. The Agency additionally found 12 8-hour TWA monitoring samples during systematic review completed by Rohm and Haas Co (Rohm and Haas, 1990). The study received a rating of low from EPA's systematic review process. With a total of 14 data points, EPA characterized the data by taking the 95th percentile and the 50th percentile of the combined dataset to represent the high-end and central tendency.

3.8.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-54 are explained in Appendix A. Since there may be mist deposited on surfaces from this OES, dermal exposures to ONUs from contact with mist on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-54 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-54. Summary of Estimated Worker Dermal Exposures for Application of Paints and Coatings

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	100	201
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.92	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.86	1.7
	Dose Rate (APDR, mg/day)	84	167

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.85	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.79	1.6
ONU	Dose Rate (APDR, mg/day)	75	75
	Acute Dose (AD) (mg/kg/day)	0.94	0.94
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	0.69	0.69
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg/day)	0.64	0.64
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.8.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-55. Summary of Estimated Worker Aggregate Exposures for Application of Paints and Coatings

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.4	3.2
	Intermediate (IADD, mg/kg-day)	1.0	2.3
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.93	2.2
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.3	3.0
	Intermediate (IADD, mg/kg-day)	0.93	2.2
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.87	2.1
ONU	Acute (AD, mg/kg-day)	1.0	1.0
	Intermediate (IADD, mg/kg-day)	0.76	0.76
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.71	0.71
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.9 Industrial Process Solvent Use

3.9.1 Process Description

In 2015, Huntsman International LLC reported their industrial use of DBP as a solvent in their maleic anhydride manufacturing technology. DBP acts as a processing agent and does not itself participate in the reactions that lead to the formation of maleic anhydride, it is also incorporated into the maleic anhydride product (Huntsman, 2015).

Huntsman International LLC uses DBP as an absorption solvent in the manufacture of maleic anhydride at two facilities in the U.S.: Pensacola, FL and Geismar, LA. The total production of maleic anhydride across both sites accounts for 47 percent of the maleic anhydride capacity in North America. Dibutyl phthalate is supplied to the sites via intermodal containers, each with a capacity of 45,000 lb. Two containers per month are typically supplied and unloaded at the Pensacola facility while one container per month is typically unloaded at the Geismar facility. The content of the container is sampled before unloading and a lab analysis is performed to verify the container content (Huntsman, 2015).

Dibutyl phthalate is unloaded by pressuring the container with nitrogen from a top vent line. Unloading is either accomplished using a dip tube or by attaching a flexible hose to a valve on the container and piping it out. The Pensacola operation has an unloading pump to assist with the movement of DBP while the Geismar operation relies on the pressure from the nitrogen pad. In both instances, the intermodal container chassis is tilted so that all of the DBP contents are removed from the container and unloaded into on-site storage tanks. The piping is blown free and clear with nitrogen before the hoses are disconnected. All the container openings are confirmed to be wrench tight and all caps are secured before the container is released. Empty intermodal containers are returned to the supplier for cleaning and disposal of residues (Huntsman, 2015).

To manufacture maleic anhydride, normal butane vapor is mixed with compressed air and is fed to a multiple tube reactor which contains a solid vanadium pyrophosphate catalyst. In the presence of the catalyst, normal butane is converted to maleic anhydride by reacting with the oxygen present in the air. While most of the normal butane is reacted to form maleic anhydride, some residual normal butane remains in the product gas from the reactor. This reaction is highly exothermic and produces high pressure steam as a significant byproduct of the process (Huntsman, 2015).

The hot product gas from the reactor is cooled and then fed to an absorber column with DBP which is used to absorb maleic anhydride from the reactor product gas. This is achieved by feeding DBP solvent from the top of the absorber while reactor product gas containing maleic anhydride is simultaneously fed from the bottom. The DBP-maleic anhydride solvent mixture from the bottom of the absorber is routed to a stripping column where the maleic anhydride is recovered from the DBP solvent. A portion of the stripped DBP solvent is fed to a solvent treater to remove undesirable impurities from the circulating solvent. The treated DBP solvent, along with the remainder of the DBP from the bottom of the stripping column, is recycled back to the top of the absorber (Huntsman, 2015).

The aqueous waste stream from the solvent treater, which contains the DBP decomposition product phthalic acid, is disposed of by deep well injection. Crude maleic anhydride from the stripping column is further purified in a refining column. When the product gas exits the top of the absorber, essentially all of the maleic anhydride has been absorbed from the product gas. Undesirable components of the product gas, such as water, are not absorbed and exit the absorber at the top. The product gas, from which essentially all of the maleic anhydride has been absorbed, is then routed to an incinerator or boiler. Unreacted butane and other components are incinerated to produce additional energy in the form of steam (Huntsman, 2015).

Figure 3-10 provides an overview of the industrial solvent use process.

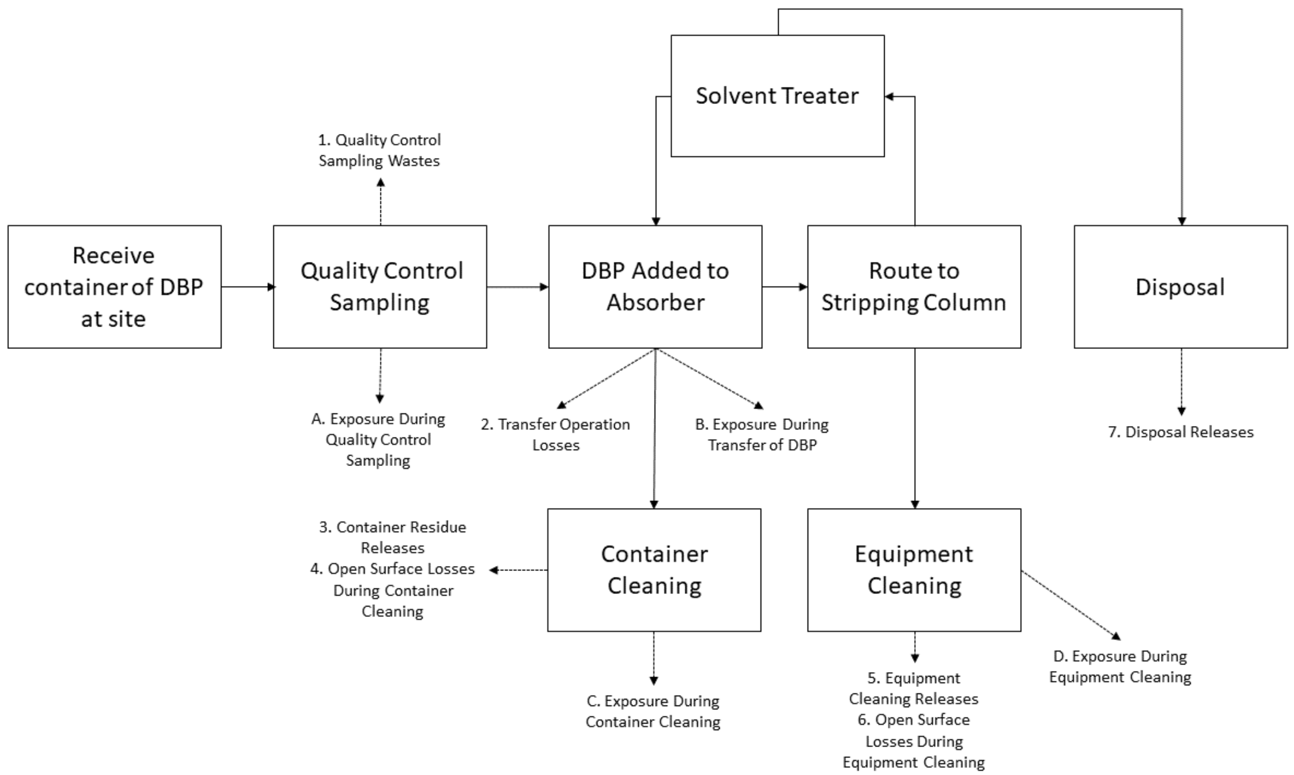


Figure 3-10. Industrial Process Solvent Use

3.9.2 Facility Estimates

In the NEI (U.S. EPA, 2023a, 2019), DMR (U.S. EPA, 2024a), and TRI (U.S. EPA, 2024e) data that EPA analyzed, EPA identified that two sites reported releases of DBP from its use as an industrial solvent in maleic anhydride production, while one additional site reported this use in CDR with their PV reported as CBI. Huntsman International, LLC operates two maleic anhydride manufacturing sites and estimated that one 45,000 lb container of DBP was used at one of their sites per month, while the other site would use two containers per month. Throughput and use rates from other processing sites are unknown. In the NEI air release data, two sites reported 250 operating days per year. TRI/DMR (U.S. EPA, 2024a, e) datasets do not report operating days; therefore, EPA assumed 250 days/year of operation as discussed in Section 2.3.2.

3.9.3 Release Assessment

3.9.3.1 Environmental Release Points

Based on TRI and NEI data, industrial process solvent use releases may go to stack air, fugitive air and additional releases may occur from transfers of wastes to off-site treatment facilities (assessed in the Waste handling, treatment, and disposal OES) (U.S. EPA, 2024e, 2023a, 2019). EPA assumed that there are no releases to water for this OES in general. Land releases were assessed using data for the Incorporation into formulation, mixture, or reaction product OES.

3.9.3.2 Environmental Release Assessment Results

Table 3-56 presents fugitive and stack air releases per year and per day based on 2017 to 2022 TRI database along with the number of release days per year, with medians and maxima presented from aacross the 6-year reporting range. Table 3-57 presents fugitive and stack air releases per year and per day based on 2020 NEI database along with the number of release days per year. Table 3-58 presents land releases per year based on the TRI database along with the number of release days per year based on surrogate data from the Incorporation into formulation, mixture, or reaction product OES. EPA assumed that there may be potential land releases from industrial process solvent use, but releases from facilities may not include releases to land. No data was reported for water releases for the Industrial process solvent use OES. Based on the identified process details and description of the use of DBP, EPA assumed that there are no releases to water for this use. The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)* and *Draft Summary of Results for Identified Environmental Releases to Land for Dibutyl Phthalate (DBP)* contain additional information about these identified releases and their original sources; refer to Appendix F for a reference to these supplemental documents.

Table 3-56. Summary of Air Releases from TRI for Industrial Process Solvent Use

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Median Annual Fugitive Air Release (kg/year)	Median Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)	Median Daily Fugitive Air Release (kg/day)	Median Daily Stack Air Release (kg/day)
Ascend Performance Materials Operations LLC	180	122	180	74	250	1.6	1.1	0.30	0.66

Table 3-57. Summary of Air Releases from NEI (2020) for Industrial Process Solvent Use

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Ascend Performance Materials Operations	180	192	250	0.72	0.77
Lanxess Corp Baytown	182	0	250	0.73	0

Table 3-58. Summary of Land Releases from TRI for Industrial Process Solvent Use (Incorporation into Formulation, Mixture, or Reaction Product)

Site Identity	Median Annual Release (kg/year)	Maximum Annual Release (kg/year)	Annual Release Days (days/year)
St. Marks Powder Inc.	510	723	250
Rubicon LLC	2,629	1.0E04	250
Century Industrial Coatings Inc.	2.7	552	250

3.9.4 Occupational Exposure Assessment

3.9.4.1 Workers Activities

During industrial process solvent use, worker exposures to DBP occur when transferring DBP from transport containers into process vessels. Worker exposures also occur via inhalation of vapor or dermal contact with liquid when cleaning transport containers, loading and unloading DBP, sampling, and cleaning equipment. EPA did not find any information on the extent to which engineering controls and worker PPE are used at facilities that use DBP in industrial process solvents.

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

3.9.4.2 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for use of industrial solvents from systematic review of literature sources. DBP is imported and manufactured as a liquid, per CDR, and EPA assessed worker inhalation exposures to DBP vapor during the unloading and loading processes. EPA used DBP manufacturing monitoring data to estimate inhalation exposures. EPA identified inhalation monitoring data from three risk evaluations, however, each study only presents a single aggregate or final data point during manufacturing of DBP. In the first source, the Syracuse Research Corporation indicates that "following a review of six studies, the American Chemistry Council has estimated exposure to di-n-butyl phthalate in the workplace based upon an assumed level of 1 mg/m^3 in the air during the production of phthalates." (SRC, 2001). The second source, a risk evaluation of 1,3,4,6,7,8-Hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-g-2-benzopyran (HHCB) conducted by European Commission, Joint Research Centre (ECJRC) presented an 8-hour TWA aggregate exposure concentration for DBP of 0.003 ppm (n = 114) for a DBP manufacturing site (ECB, 2008). The third source, a risk evaluation of DBP also conducted by the ECJRC provides seven separate datasets from two unnamed manufacturers. Of these datasets six did not include a sampling method and were not used. Only one had sufficiently detailed metadata (*e.g.*, exposure duration, sample type) to include in this assessment; an 8-hour TWA worker exposure concentration to DBP of 0.5 mg/m^3 from DBP production (ECB, 2004). With three aggregate or final concentration value from three sources, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the manufacturing process, EPA used the maximum available value (1 mg/m^3). The Agency assessed the midpoint of the three available values as the central tendency (0.5 mg/m^3). All three sources of monitoring data received a rating of medium from EPA's systematic review process.

Table 3-3 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during manufacture. In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. The central tendency and high-end exposures use 250 days per year as the exposure frequency, which is the expected maximum for working days. Appendix A describes the approach for estimating AD, IADD, and ADD. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-59. Summary of Estimated Worker Inhalation Exposures for Industrial Process Solvent Use

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.50	1.0
	Acute Dose (AD) (mg/kg-day)	6.3E−02	0.13
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−02	9.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−02	8.6E−02
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.50	1.0
	Acute Dose (AD) (mg/kg-day)	6.9E−02	0.14
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	5.1E−02	0.10
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.7E−02	9.5E−02
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.50	0.50
	Acute Dose (AD) (mg/kg-day)	6.3E−02	6.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−02	4.6E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−02	4.3E−02

[a] EPA identified surrogate inhalation monitoring data from three sources to estimate exposures for this OES (ECB, 2008, 2004; SRC, 2001). All three sources of monitoring data received a rating of medium from EPA's systematic review process. With the three discrete data points, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the manufacturing process, EPA used the maximum available value (1 mg/m^3). EPA assessed the midpoint of the three available values as the central tendency (0.5 mg/m^3).

3.9.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-60 are explained in Appendix A. ONU dermal exposures are not assessed for this OES as there are no activities expected to expose ONUs to DBP liquid. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper PPE or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-60 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-60. Summary of Estimated Worker Dermal Exposures for Industrial Process Solvent Use

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	100	201
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.92	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.86	1.7
Female of Reproductive Age	Dose Rate (APDR, mg/day)	84	167
	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.85	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.79	1.6

Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).

3.9.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A to arrive at the aggregate worker and ONU exposure estimates in Table 3-61 below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-61. Summary of Estimated Worker Aggregate Exposures for Industrial Process Solvent Use

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.3	2.6
	Intermediate (IADD, mg/kg-day)	0.97	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.90	1.8
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.2	2.5
	Intermediate (IADD, mg/kg-day)	0.90	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.84	1.7
ONU	Acute (AD, mg/kg-day)	6.3E−02	6.3E−02
	Intermediate (IADD, mg/kg-day)	4.6E−02	4.6E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	4.3E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.10 Use of Laboratory Chemicals

3.10.1 Process Description

Multiple products identified in the Use Report for DBP confirm that DBP is used as a laboratory chemical (see Appendix E for EPA identified DBP-containing products for this OES). One industry commenter reported the use of DBP in laboratory use including such applications as analytical standards, research, equipment calibration, sample preparation and as a component of a variety of other common off the shelf materials, including anti-seize compound (U.S. EPA-HQ-OPPT-2018-0503-0035). EPA identified relevant SDS that indicate laboratory chemicals containing DBP in a concentration of 0.1 to 10 percent for liquid products or concentrations from 0.3 to 20 percent for solids.

EPA did not identify DBP-specific laboratory procedures. Based on the 2023 GS on Laboratory Chemicals, EPA expects laboratory chemicals containing DBP to arrive at end use sites in 1-gallon bottles for liquid chemicals or in 1 kg containers for solids based on a 1 L container and a density of 1 kg/L (U.S. EPA, 2023d). The size of the container is an input to the Monte Carlo simulation to estimate releases but is not used to calculate occupational exposures for DBP. EPA expects the end use site to transfer the chemical to labware and lab equipment for analyses. After analysis, laboratory sites clean containers, labware, and lab equipment and dispose of laboratory waste and unreacted DBP-containing laboratory chemicals. Figure 3-11 provides an illustration of the use of laboratory chemicals (U.S. EPA, 2023d).

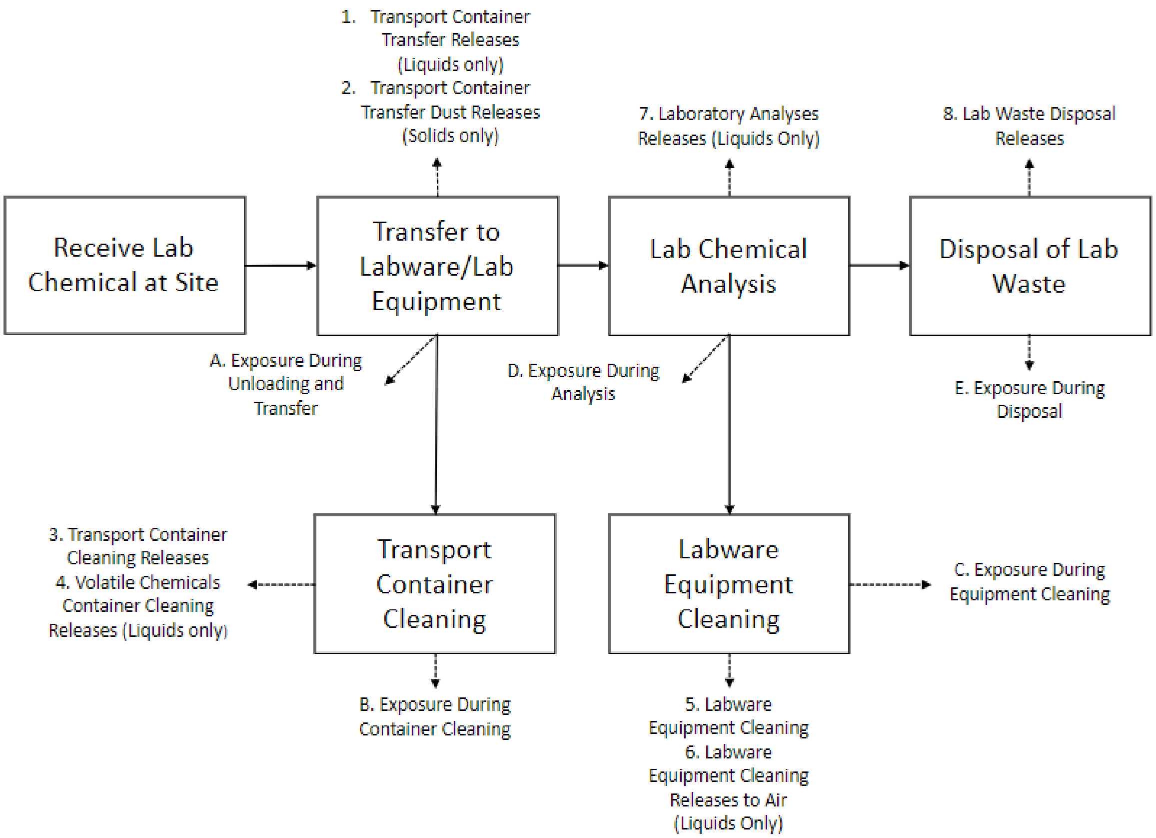


Figure 3-11. Use of Laboratory Chemicals Flow Diagram (U.S. EPA, 2023d)

3.10.2 Facility Estimates

No sites reported to CDR for use of DBP in laboratory chemicals. EPA estimated the total production volume (PV) for all sites of 215,415 lb/year (97,710 kg/year) that was estimated based on the reporting requirements for CDR. The threshold for CDR reporters requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year. For the 12 sites that reported to CDR for the manufacture or import of DBP, EPA assumed that each site used DBP for laboratory chemicals in volumes up to the reporting threshold limit of 5 percent of their reported PV. If 5 percent of each site's reported PV exceeds the 25,000 lb reporting limit, EPA assumed the site used only 25,000 lb annually as an upper-bound. If the site reported a PV that was CBI, EPA assumed the maximum PV contribution of 25,000 lb. The CDR sites and their PV contributions to this OES are shown in Table_Apx D-13.

EPA did not identify site- or chemical-specific operating data for laboratory use of DBP (*i.e.*, facility throughput). For solid products, the 2023 GS on The Use of Laboratory Chemicals provides an estimated throughput of 0.33 kg/site-day for solid laboratory chemicals (U.S. EPA, 2023d). Based on the concentration of DBP in the laboratory chemical of 0.3 to 20 percent, EPA estimated a daily facility use rate using Monte Carlo modeling, resulting in a 50th to 95th percentile range of 1.2×10^{-2} to 5.3×10^{-2} kg/site-day. For liquid products, the 2023 GS provided an estimated throughput of 0.5 to 4,000 mL/site-day for liquid laboratory chemicals (U.S. EPA, 2023d). Based on the concentration of DBP in liquid laboratory chemicals of 0.1 to 10 percent, (see Appendix E for EPA identified DBP-containing products for this OES) and the DBP density of 1.0 kg/L, EPA estimated a daily facility use rate of laboratory chemicals using Monte Carlo modeling, resulting in a 50th to 95th percentile range of 4.8×10^{-2} to 0.22

kg/site-day. Additionally, the GS estimated the number of operating days as 174 to 260 days/year, with 8 to 12 hours/day operations (U.S. EPA, 2023d). This range of operating days was used for the modeled releases, while the two NEI sites both reported 365 release days per year.

Two laboratories reported air releases in the 2020 NEI; however, there were no other reported releases from laboratories, and it is unlikely that only two laboratories in the United States use products that contain DBP. Therefore, EPA estimated the total number of sites that use DBP-containing laboratory chemicals using a Monte Carlo model (see Appendix D for details). Both the 50th and 95th percentile results for the number of sites were the bounding estimate of 36,873 for the liquid use case. For the solid use case, the 50th to 95th percentile range of the number of sites was 1,978 to 25,643.

3.10.3 Release Assessment

3.10.3.1 Environmental Release Points

EPA assigned release points based on the 2023 GS on the Use of Laboratory Chemicals (U.S. EPA, 2023d) and based on NEI and TRI data (U.S. EPA, 2024e, 2023a, 2019). In the solid laboratory chemical use case, EPA expects sites to release dust emissions from transferring powders containing DBP to stack or fugitive air, water, incineration, or landfill. In both liquid and solid use cases, EPA expects water, incineration, or landfill releases from container cleaning wastes, labware equipment cleaning wastes, and laboratory waste disposal.

3.10.3.2 Environmental Release Assessment Results

Table 3-62 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES. Table 3-63 presents fugitive and stack air releases per year and per day based on 2020 NEI database along with the number of release days per year. The GS identified models to quantify releases from each release point for water, incineration and landfill, and NEI data provided air emissions data, so modeled air emissions are not presented. Laboratory sites may use a combination of solid and liquid laboratory chemicals, but for release modeling, EPA assumed each site used either the liquid or solid form (not both) of the DBP-containing laboratory chemical. See Appendix D.5.2 for additional details on model equations and parameters. The *Draft Use of Laboratory Chemicals OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP)* contains additional information about model equations and parameters and contains calculation results. The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)* contains additional information about identified air releases and their original sources, refer to Appendix F for a reference to these supplemental documents.

Table 3-62. Summary of Modeled Environmental Releases for Use of Laboratory Chemicals

Modeled Scenario	Environmental Media	Annual Release (kg/site-year)		Number of Release Days		Daily Release (kg/site-day)[b]	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
97,710 kg/year production volume – Liquid Laboratory Chemicals	Fugitive Air	NEI data		365		NEI data	
	Water, Incineration, or Landfill[a]	17	80			4.8E−02	0.22
97,710 kg/year production volume – Solid Laboratory Chemicals	Fugitive Air	NEI data		365		NEI data	
	Unknown Media (Air, Water, Incineration, or Landfill)[a]	1.5E−02	0.11			4.0E−05	2.9E−04
	Water, Incineration, or Landfill[a]	4.3	19			1.2E−02	5.2E−02
	Incineration or Landfill[a]	1.9E−02	0.13			5.3E−05	3.5E−04

[a] When multiple environmental media are addressed together, releases may go all to one media, or be split between media depending on site-specific practices. Not enough data was provided to estimate the partitioning between media.
[b] For the modeling releases, the Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table 3-63. Summary of NEI (2020) for Use of Laboratory Chemicals

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
University of California Merced	1.2E−02	N/A	364	3.4E−05	N/A
Los Alamos National Laboratory	2.7	N/A	365	7.5E−03	N/A

3.10.4 Occupational Exposure Assessment

3.10.4.1 Worker Activities

Worker exposures to DBP may occur through the inhalation of solid powders while unloading and transferring laboratory chemicals and during laboratory analysis. Dermal exposure to liquid and solid chemicals may occur during laboratory chemical unloading, container cleaning, labware equipment cleaning, laboratory analysis, and disposal of laboratory wastes (U.S. EPA, 2023d). EPA did not find information on the extent to which laboratories that use DBP-containing chemicals also use engineering controls and worker PPE.

ONUs include supervisors, managers, and other employees that do not directly handle the laboratory chemical or laboratory equipment but may be present in the laboratory or analysis area. ONUs are potentially exposed through the inhalation route while in the laboratory area from airborne dust and through the dermal route from contact with surfaces where dust has been deposited.

3.10.4.2 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the use of laboratory chemicals during systematic review. DBP is present in solid and liquid laboratory chemicals. EPA assessed potential for worker and ONU inhalation to dust from solid laboratory chemicals and vapor from liquid laboratory chemicals. No vapor inhalation exposure data was found, and EPA used data from the adhesives and sealants OES as a surrogate data source due to the expected similarity in usage and concentrations. Assumption has been made that laboratory workers use the chemicals on the benchtop similar to the usage of adhesives. The adhesives and sealant data consists of 19 monitoring samples in a NIOSH HHE (NIOSH, 1977), which received a rating of medium from EPA's systematic review process. Six of the samples were PBZ samples, and the remaining 13 samples were area samples taken at various locations around an acrylic furniture manufacturing site. With all samples at or below the LOD, EPA assessed inhalation exposures as a range from zero to the LOD. EPA estimated the high-end exposure as equal to the LOD and the central tendency as the midpoint (*i.e.*, half the LOD).

To estimate worker and ONU inhalation exposure to dust for the use of solid laboratory chemicals, EPA used the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are detailed in Appendix D. EPA used a subset of the model data that came from facilities with the NAICS code starting with 54 – Professional, Scientific, and Technical Services – to estimate DBP-containing particulate concentrations in the air. EPA used the highest expected concentration of DBP to estimate the concentration of DBP in particulates. For the Use of laboratory chemicals OES, the highest expected concentration of DBP is 20 percent by mass based on identified lab-grade chemicals. The estimated exposures assume that DBP is present in particulates at this fixed concentration throughout the working shift.

The *Generic Model for Central Tendency and High-End Inhalation Exposure to Total and Respirable Particulates Not Otherwise Regulated (PNOR)*(U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. For both vapor and dust exposures EPA used the number of operating days estimated in the release assessment for this OES to estimate exposure frequency, which is the expected maximum number of working days. EPA assessed the exposure frequency as 250 days/year for both high-end and central tendency exposures based on the expected operating days for the OES and accounting for off days for workers. In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure is representative of ONU exposure and were used to generate estimates for ONUs.

Table 3-64 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during the use of solid laboratory chemicals. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP in the form of particulates or vapors. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data, information on the PNOR Model parameters used, and assumptions used in the assessment; refer to Appendix F for a reference to this supplemental document.

Table 3-64. Summary of Estimated Worker Inhalation Exposures for Use of Laboratory Chemicals

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker – Solids	8-hour TWA Exposure Concentration (mg/m^3)	3.8E−02	0.54
	Acute Dose (AD) (mg/kg-day)	4.8E−03	6.8E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.5E−03	5.0E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.3E−03	4.6E−02
Female of Reproductive Age – Solids	8-hour TWA Exposure Concentration (mg/m^3)	3.8E−02	0.54
	Acute Dose (AD) (mg/kg-day)	5.2E−03	7.5E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.8E−03	5.5E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.6E−03	5.1E−02
ONU – Solids	8-hour TWA Exposure Concentration (mg/m^3)	3.8E−02	3.8E−02
	Acute Dose (AD) (mg/kg-day)	4.8E−03	4.8E−03
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	3.5E−03	3.5E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.3E−03	3.3E−03
Average Adult Worker – Liquids	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	0.10
	Acute Dose (AD) (mg/kg-day)	6.3E−03	1.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−03	9.2E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−03	8.6E−03
Female of Reproductive Age – Liquids	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	0.10
	Acute Dose (AD) (mg/kg-day)	6.9E−03	1.4E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	5.1E−03	1.0E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.7E−03	9.5E−03
ONU – Liquids	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	5.0E−02
	Acute Dose (AD) (mg/kg-day)	6.3E−03	6.3E−03
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−03	4.6E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−03	4.3E−03

[a] EPA used surrogate monitoring data for adhesive application as described by 19 monitoring samples in NIOSH's HHE database (NIOSH, 1977), which received a rating of medium from EPA's systematic review process. The Agency estimated the high-end exposure as equal to the LOD and the central tendency as the midpoint (*i.e.*, half the LOD). For the PNOR Model, EPA multiplied the concentration of DBP with the central tendency and HE estimates of the relevant NAICS code from the PNOR Model to calculate the central tendency and HE estimates for this OES.

3.10.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. The various "Exposure Concentration Types" from Table 3-65 are explained in Appendix A. For solid laboratory chemicals, since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. Table 3-65 summarizes the APDR, the AD, the IADD, and the ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-65. Summary of Estimated Worker Dermal Exposures for Use of Laboratory Chemicals

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker – Solid	Dose Rate (APDR, mg/day)	1.4	2.7
	Acute (AD, mg/kg-day)	1.7E−02	3.4E−02
	Intermediate (IADD, mg/kg-day)	1.2E−02	2.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−02	2.3E−02
Female of Reproductive Age – Solid	Dose Rate (APDR, mg/day)	1.1	2.3
	Acute (AD, mg/kg-day)	1.7E−02	3.1E−02
	Intermediate (IADD, mg/kg-day)	1.1E−02	2.3E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.1E−02	2.1E−02
ONU – Solid	Dose Rate (APDR, mg/day)	1.4	1.4
	Acute (AD, mg/kg-day)	1.9E−02	1.9E−02
	Intermediate (IADD, mg/kg-day)	1.4E−02	1.4E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.3E−02	1.3E−02
Average Adult Worker – Liquid	Dose Rate (APDR, mg/day)	75	201
	Acute (AD, mg/kg-day)	0.94	2.5
	Intermediate (IADD, mg/kg-day)	0.69	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.64	1.7
Female of Reproductive Age – Liquid	Dose Rate (APDR, mg/day)	62	167
	Acute (AD, mg/kg-day)	0.86	2.3
	Intermediate (IADD, mg/kg-day)	0.63	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.59	1.6

Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).

3.10.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-66. Summary of Estimated Worker Aggregate Exposures for Use of Laboratory Chemicals

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker – Solid	Acute (AD, mg/kg-day)	2.2E−02	0.10
	Intermediate (IADD, mg/kg-day)	1.6E−02	7.4E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−02	6.9E−02
Female of Reproductive Age – Solid	Acute (AD, mg/kg-day)	2.1E−02	0.11
	Intermediate (IADD, mg/kg-day)	1.5E−02	7.8E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.4E−02	7.2E−02
ONU – Solid	Acute (AD, mg/kg-day)	2.2E−02	2.2E−02
	Intermediate (IADD, mg/kg-day)	1.6E−02	1.6E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.5E−02	1.5E−02
Average Adult Worker – Liquid	Acute (AD, mg/kg-day)	0.94	2.5
	Intermediate (IADD, mg/kg-day)	0.69	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.65	1.7
Female of Reproductive Age – Liquid	Acute (AD, mg/kg-day)	0.87	2.3
	Intermediate (IADD, mg/kg-day)	0.64	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.59	1.6
ONU – Liquid	Acute (AD, mg/kg-day)	6.3E−03	6.3E−03
	Intermediate (IADD, mg/kg-day)	4.6E−03	4.6E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−03	4.3E−03
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.11 Use of Lubricants and Functional Fluids

3.11.1 Process Description

DBP is used as a functional fluid for processes in printing and related support activities and is also used as a lubricant such as textile fiber lubricant in industrial processes (see Appendix E for EPA identified DBP-containing products for this OES). A typical end use site unloads the lubricant/functional fluid when ready for changeout (OECD, 2004b). Sites incorporate the product into the system with a frequency ranging from once every 3 months to once every 5 years. After changeout, sites clean the transport containers and equipment and dispose of used fluid. Figure 3-12 provides an illustration of the expected use of lubricants and functional fluids process (OECD, 2004b).

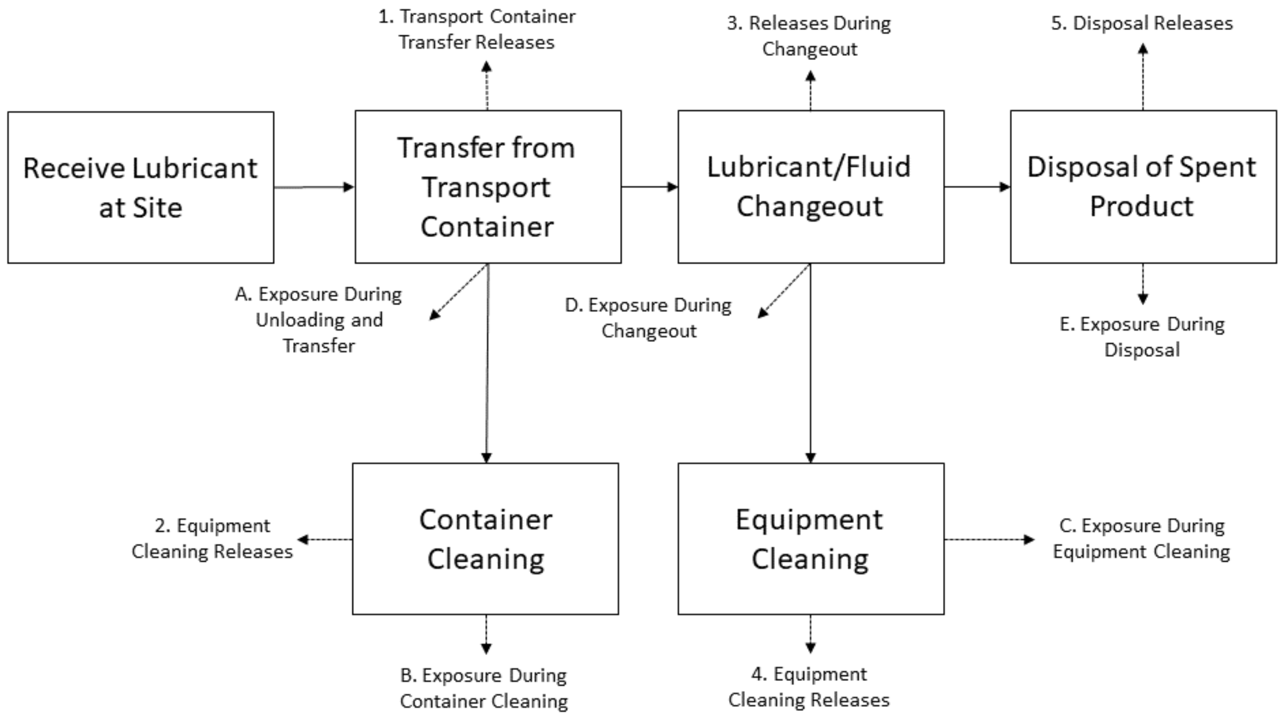


Figure 3-12. Use of Lubricants and Functional Fluids Flow Diagram

3.11.2 Facility Estimates

No sites reported to CDR for use of DBP in lubricants or functional fluids. EPA estimated the total production volume (PV) for all sites assuming a static value of 215,415 lb/year (97,710 kg/year) that was estimated based on the reporting requirements for CDR. The threshold for CDR reporters requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year. For the 12 sites that reported to CDR for the manufacture or import of DBP, EPA assumed that each site used DBP for lubricants or functional fluids in volumes up to the reporting threshold limit of 5 percent of their reported PV. If 5 percent of each site's reported PV exceeds the 25,000 lb reporting limit, EPA assumed the site used only 25,000 lb annually as an upper-bound. If the site reported a PV that was CBI, EPA assumed the maximum PV contribution of 25,000 lb. The CDR sites and their PV contributions to this OES are shown in Table_Apx D-13.

EPA did not identify site- or DBP-specific lubricant and functional fluid use operating data (*e.g.*, facility use rates, operating days). However, based on the 2004 ESD on Lubricants and Lubricant Additives, EPA assumed a product throughput equivalent to one container per lubricant/functional fluid changeout (OECD, 2004b).

The ESD provides an estimate of 1 to 4 changeouts per year for different types of lubricant/functional fluids, and EPA assumed each changeout occurs over the course of 1 day. Based on this relationship, the EPA assessed 1 to 4 operating days per year. Based on this operating day distribution, the 50th and 95th percentile range of the resulting DBP use rate was 14 to 47 kg/site-year. EPA did not identify any estimates of the number of sites that may use lubricants/functional fluids containing DBP. Therefore, EPA estimated the total number of sites that use DBP-containing lubricants/functional fluids using a

Monte Carlo model (see Appendix D.6 for details). The 50th to 95th percentile range of the number of sites was 3,337 to 39,808 sites.

3.11.3 Release Assessment

3.11.3.1 Environmental Release Points

EPA assigned release points based on the 2004 ESD on Lubricants and Lubricant Additives (OECD, 2004b). EPA assigned models to quantify releases from each release point. EPA expects releases to wastewater or landfill during the use of equipment. Releases to wastewater, landfill, recycling, and incineration during the changeout of lubricants and functional fluids are expected.

3.11.3.2 Environmental Release Assessment Results

Table 3-67 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES. See Appendix D.6.2 for additional details on model equations and, and different parameters used for used for Monte Carlo modeling. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively. The *Draft Use of Lubricants and Functional Fluids OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP)* also contains additional information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-67. Summary of Modeled Environmental Releases for Use of Lubricants and Functional Fluids

Modeled Scenario	Environmental Media	Annual Release (kg/site-year)		Number of Release Days		Daily Release[a] (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
97,710 kg/year production volume	Land	6.4	35	2	4	3.0	13
	Water	15	74			6.8	26
	Recycling	0.22	1.7			0.11	0.62
	Fuel Blending (Incineration)	5.0	37			2.3	14

[a] The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.11.4 Occupational Exposure Assessment

3.11.4.1 Worker Activities

Workers are potentially exposed to DBP from lubricant and functional fluid use when unloading lubricants and functional fluids from transport containers, during changeout and removal of used lubricants and functional fluids, and during any associated equipment or container cleaning activities. Workers may be exposed via inhalation of DBP vapors or dermal contact with liquids containing DBP. EPA did not identify chemical-specific information for engineering controls and worker PPE used at facilities that perform changeouts of lubricants or functional fluids.

ONUs include supervisors, managers, and other employees that may be in the area when changeouts occur but do not perform changeout tasks. ONUs are potentially exposed via inhalation but have no expected dermal exposure.

3.11.4.2 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for use of lubricants and functional fluids during systematic review of literature sources. However, EPA estimated inhalation exposures for this OES using monitoring data for DBP exposures during the application of adhesives and sealants. EPA expects that inhalation exposures during the application of adhesives and sealants are similar to inhalation exposures expected during use of lubricants and functional fluids and serve as reasonable surrogate.

EPA used surrogate monitoring data for adhesive application as described by 19 monitoring samples in NIOSH's HHE database (NIOSH, 1977), which received a rating of medium from EPA's systematic review process. Six of the samples were PBZ samples, and the remaining 13 samples were area samples taken at various locations around an acrylic furniture manufacturing site. The site uses 2-part adhesives where the part B component is 96.5 percent DBP. EPA assessed inhalation exposures as a range from 0 to the LOD. EPA estimated the high-end exposure as equal to the LOD and the central tendency as the midpoint (*i.e.*, half the LOD).

Table 3-68 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during use of lubricants and functional fluids. The high-end exposures use 4 days per year as the exposure frequency based on the 95th percentile of operating days from the release assessment. The central tendency exposures use two days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. Appendix A describes the approach for estimating AD, IADD, and ADD. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data and assumptions used in the assessment, refer to Appendix F for a reference to this supplemental document.

Table 3-68. Summary of Estimated Worker Inhalation Exposures for Use of Lubricants and Functional Fluids

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	0.10
	Acute Dose (AD) (mg/kg-day)	6.3E−03	1.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.2E−04	1.7E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.4E−05	1.4E−04
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	0.10
	Acute Dose (AD) (mg/kg-day)	6.9E−03	1.4E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.6E−04	1.8E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.8E−05	1.5E−04
ONU	8-hour TWA Exposure Concentration (mg/m^3)	5.0E−02	5.0E−02
	Acute Dose (AD) (mg/kg-day)	6.3E−03	6.3E−03
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.2E−04	8.3E−04

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	3.4E−05	6.8E−05
[a] EPA used surrogate monitoring data for adhesive application as described by 19 monitoring samples in NIOSH's HHE database (NIOSH, 1977), which received a rating of medium from EPA's systematic review process. The Agency estimated the high-end exposure as equal to the LOD and the central tendency as the midpoint (*i.e.*, half the LOD).			

3.11.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper PPE or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. The various "Exposure Concentration Types" from Table 3-69 are explained in Appendix A. Table 3-69 summarizes the APD), AD, the IADD, and the ADD for both average adult workers and female workers of reproductive age. Because there is no dust or mist expected to be deposited on surfaces from this OES, dermal exposures to ONUs from contact with surfaces were not assessed. Dermal exposure parameters are described in Appendix C. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-69. Summary of Estimated Worker Dermal Exposures for Use of Lubricants and Functional Fluids

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	56	169
	Acute (AD, mg/kg-day)	0.70	2.1
	Intermediate (IADD, mg/kg-day)	4.7E−02	0.28
	Chronic, Non-Cancer (ADD, mg/kg-day)	3.8E−03	2.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	47	140
	Acute (AD, mg/kg-day)	0.65	1.9
	Intermediate (IADD, mg/kg-day)	4.3E−02	0.26
	Chronic, Non-Cancer (ADD, mg/kg-day)	3.5E−03	2.1E−02
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.11.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-70. Summary of Estimated Worker Aggregate Exposures for Use of Lubricants and Functional Fluids

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	0.71	2.1
	Intermediate (IADD, mg/kg-day)	4.7E−02	0.28
	Chronic, Non-Cancer (ADD, mg/kg-day)	3.9E−03	2.3E−02
Female of Reproductive Age	Intermediate (IADD, mg/kg-day)	0.65	1.9
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.3E−02	0.26
	Chronic, Cancer (LADD, mg/kg-day)	3.6E−03	2.1E−02
ONU	Acute (AD, mg/kg-day)	6.3E−03	6.3E−03
	Chronic, Non-Cancer (ADD, mg/kg-day)	4.2E−04	8.3E−04
	Chronic, Cancer (LADD, mg/kg-day)	3.4E−05	6.8E−05
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.12 Use of Penetrants and Inspection Fluids

3.12.1 Process Description

One comment from industry identified the commercial use of DBP in inspection penetrant kits; however, EPA was unable to identify any penetrants or inspection fluid products that contained DBP (U.S. EPA-HQ-OPPT-2018-0503-0036). According to the ESD on metalworking fluids, concentrations of additives can range from less than one percent to less than 80 percent (OECD, 2011c). EPA assessed aerosol-based penetrants and non-aerosol penetrants as separate processes with unique release points. EPA expects that sites receive aerosol penetrants in 0.082-gallon containers based on a 10.5-oz aerosol product can and non-aerosol penetrants in bottles, cans, or drums, ranging in size from 0.082 to 55 gallons, with the maximum container size based on the ESD default for drums and the minimum based on a 10.5-oz aerosol product can (OECD, 2011c). The size of the container is an input to the Monte Carlo simulation to estimate releases but is not used to calculate occupational exposures.

The site transfers the non-aerosol penetrant from transport containers into process vessels and applies the product using brushing and/or immersion. EPA expects that non-aerosol penetrant application occurs over the course of an 8-hour workday A typical site that uses aerosol penetrants receives cans of penetrant and an operator sprays the aerosol penetrant and disposes of the used aerosol can. EPA expects the operator to apply the aerosol in non-steady, instantaneous bursts at the start of each job, and allow the penetrant to remain on the surface as it reveals defects before eventually wiping it away. EPA expects that the penetrant product is self-contained and does not require transfer or cleaning from shipping containers or application equipment for this OES. Figure 3-13 and Figure 3-14 provide illustrations of the use of inspection fluids or penetrants for the non-aerosol and aerosol use cases respectively (OECD, 2011c).

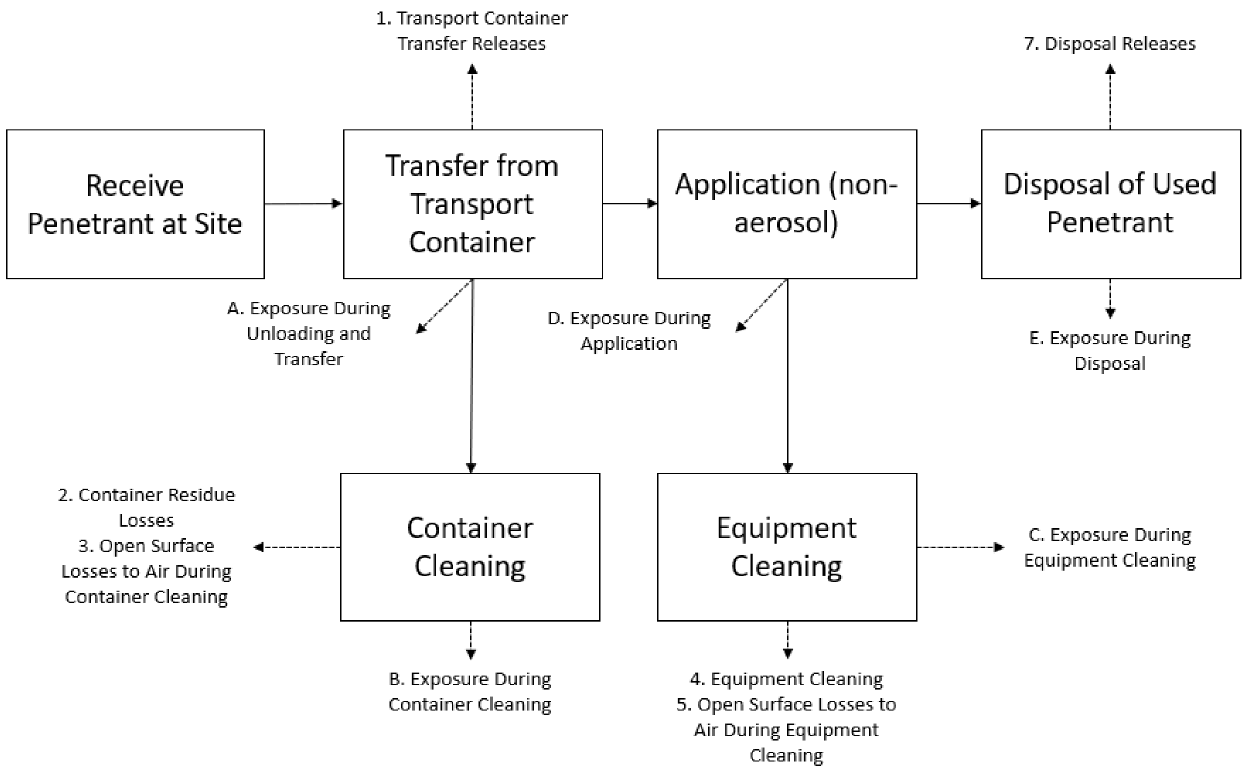


Figure 3-13. Use of Penetrants and Inspection Fluids Flow Diagram Non-Aerosol Use ([OECD, 2011c](#))

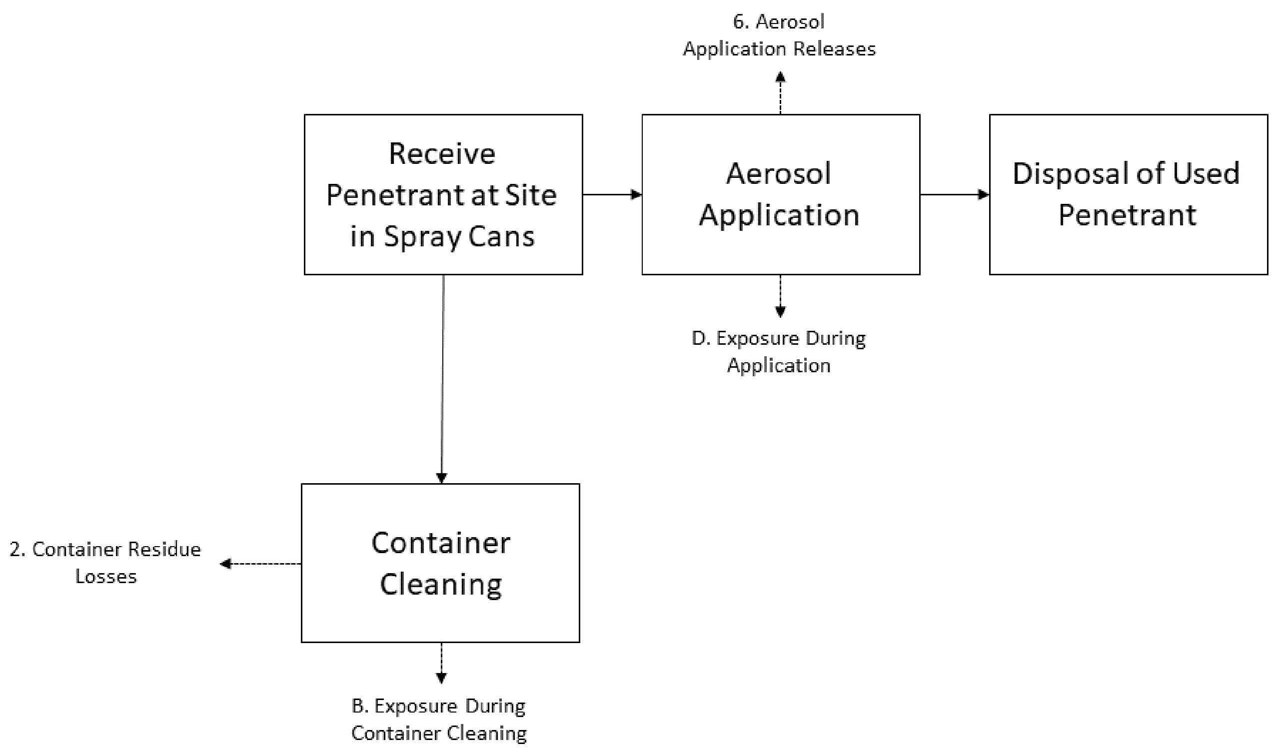


Figure 3-14. Use of Penetrants and Inspection Fluids Flow Diagram Aerosol Use ([OECD, 2011c](#))

3.12.2 Facility Estimates

No sites reported to CDR for use of DBP in penetrants or inspection fluids. EPA estimated the total production volume (PV) for all sites assuming a static value of 215,415 lb/year (97,710 kg/year) that was estimated based on the reporting requirements for CDR. The threshold for CDR reporters requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year. For the 12 sites that reported to CDR for the manufacture or import of DBP, EPA assumed that each site used DBP for penetrants or inspection fluids in volumes up to the reporting threshold limit of 5 percent of their reported PV. If 5 percent of each site's reported PV exceeds the 25,000 lb reporting limit, EPA assumed the site used only 25,000 lb annually as an upper-bound. If the site reported a PV that was CBI, EPA assumed the maximum PV contribution of 25,000 lb. The CDR sites and their PV contributions to this OES are show in Table_Apx D-13.

EPA did not identify site- or DBP-specific inspection fluid/penetrant site operating data (*i.e.*, batch size or number of batches per year) from systematic review; therefore, EPA assessed the daily DBP facility throughput of 1.81×10^{-2} to 3.62×10^{-2} kg/site-day based on a penetrant product throughput of eight 10.5-oz cans per day (1 can of product per hour), and a concentration of DBP in inspection fluid/penetrant products of 10 to 20 percent based on the concentration of DINP in penetrants (Appendix F of the *Environmental Release and Occupational Exposure Assessment for Diisononyl Phthalate (DINP)* (U.S. EPA, 2024b). EPA assessed the number of operating days using the 2011 ESD on the Use of Metalworking Fluids, which cites general averages for facilities with a range of 246 to 249 operating days/year of 8 hour/day, 5 days/week operations up to the operating days for the given site throughput scenario (OECD, 2011c). EPA assessed the total number of sites that use DBP-containing inspection fluids/penetrants using a Monte Carlo model that considered the total production volume for this OES and the annual DBP facility throughput of 0.027 to 0.035 kg/site-year. The 50th to 95th percentile range of the number of sites was 14,538 to 20,770 (non-aerosol run) and 14,541 to 20,767 (aerosol run).

3.12.3 Release Assessment

3.12.3.1 Environmental Release Points

EPA assigned release points based on the 2011 ESD on the Use of Metalworking Fluids (OECD, 2011c). EPA assigned models to quantify releases from each release point and suspected fugitive air release. For the aerosol penetrant use case, EPA expects releases to wastewater, incineration, or landfill from container residue losses and aerosol application processes. EPA also expects fugitive air releases from aerosol application. For the non-aerosol penetrant use case, EPA expects releases to fugitive air from unloading penetrant containers, container cleaning, and equipment cleaning. EPA expects wastewater, incineration, or landfill releases from container residue losses, equipment cleaning, and disposal of used penetrant.

3.12.3.2 Environmental Release Assessment Results

Table 3-71 summarizes the number of release days and the annual and daily release estimates that were modeled for each release media and scenario assessed for this OES. See Appendix D.7.2 for additional details on model equations, and different parameters used for used for Monte Carlo modeling. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th percentile and 95th percentile values to estimate the central tendency and high-end releases, respectively. The *Draft Use of Penetrants OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP)* also contains additional information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-71. Summary of Modeled Environmental Releases for Use of Penetrants and Inspection Fluids

Modeled Scenario	Environmental Media	Annual Release (kg/site-year)		Number of Release Days		Daily Release[b] (kg/site-day)	
		Central Tendency	High-End	Central Tendency	High-End	Central Tendency	High-End
97,710 kg/year production volume Aerosol Based	Fugitive Air	0.99	1.3	247	249	4.0E−03	5.2E−03
	Wastewater, Incineration, or Landfill[a]	5.7	7.4			2.3E−02	3.0E−02
97,710 kg/year production volume Non-Aerosol Based	Fugitive Air	1.6E−05	3.0E−05	247	249	6.4E−08	1.2E−07
	Wastewater, Incineration, or Landfill[a]	6.7	8.7			2.7E−02	3.5E−02

[a] When multiple environmental media are addressed together, releases may go all to one media, or be split between media depending on site-specific practices. Not enough data was provided to estimate the partitioning between media.
[b] The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

3.12.4 Occupational Exposure Assessment

3.12.4.1 Worker Activities

Worker exposures during the use of penetrant and inspection fluids may occur via dermal contact with liquids when applying the product to substrate from the container for non-aerosol application and inhalation and dermal contact when applying via aerosol application. Worker exposures may also occur via vapor inhalation and dermal contact with liquids during aerosol application, equipment cleaning, container cleaning, and disposal of used penetrants (OECD, 2011c). EPA did not identify chemical-specific information on the use of engineering controls and worker PPE used at facilities that use DBP-containing penetrants and inspection fluids.

ONUs include supervisors, managers, and other employees that are in the application area but do not directly use or contact penetrants. ONU exposure may occur via inhalation while the ONU is present in the application area. Also, dermal exposures from contact with surfaces where mist has been deposited were assessed for ONUs.

3.12.4.2 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data for the use of penetrants and inspection fluids during systematic review of literature sources. However, through review of the literature and consideration of existing EPA/OPPT exposure models, EPA identified the Brake Servicing Near-Field/Far-Field Inhalation Exposure Model as an appropriate approach for estimating occupational exposures to DBP-containing aerosols. The model is based on a near-field/far-field approach (AIHA, 2009), where aerosol application in the near-field generates a mist of droplets and indoor air movements lead to the convection of droplets between the near-field and far-field. The model assumes workers are exposed to DBP droplets in the near-field, while ONUs are exposed in the far-field.

Penetrant/inspection fluid application generates a mist of droplets in the near-field, resulting in worker exposures. The DBP exposure concentration is directly proportional to the amount of penetrant applied by the worker standing in the near-field zone (*i.e.*, the working zone). The ventilation rate for the near-field zone determines the rate of DBP dissipation into the far-field (*i.e.*, the facility space surrounding the near-field), resulting in occupational bystander exposures to DBP. The ventilation rate of the surroundings determines the rate of DBP dissipation from the surrounding space into the outside air.

Table 3-72 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during the use of penetrants and inspection fluids. The high-end exposures use 249 days per year as the exposure frequency based on the 95th percentile of operating days from the release assessment. The central tendency exposures use 247 days per year as the exposure frequency based on the 50th percentile of operating days from the release assessment. Appendix A describes the approach for estimating AD, IADD, and ADD. The *Draft Use of Penetrants OES Occupational Inhalation Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-72. Summary of Estimated Worker Inhalation Exposures for Use of Penetrants and Inspection Fluids

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	1.5	5.6
	Acute Dose (AD) (mg/kg-day)	0.19	0.70
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	0.14	0.51
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	0.13	0.48
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	1.5	5.6
	Acute Dose (AD) (mg/kg-day)	0.21	0.77
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	0.15	0.56
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	0.14	0.53
ONU	8-hour TWA Exposure Concentration (mg/m^3)	5.1E−02	0.38
	Acute Dose (AD) (mg/kg-day)	6.4E−03	4.7E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	4.7E−03	3.5E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	4.3E−03	3.2E−02

[a] From monte carlo modeling, EPA selected the 95th percentile value to represent high-end exposure level and the 50th percentile value to represent the central tendency exposure level.

3.12.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the methodology outlined in Appendix C. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. The various “Exposure Concentration Types” from Table 3-73 are explained in Appendix A. Since there may be mist deposited on surfaces from this OES, dermal exposures to ONUs from contact with mist on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure.

Table 3-73 summarizes the APDR, the AD, the IADD, and the ADD for average adult workers, female workers of reproductive age, and ONUs. Dermal exposure parameters are described in Appendix C. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-73. Summary of Estimated Worker Dermal Exposures for Use of Penetrants and Inspection Fluids

Worker Population	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	100	201
	Acute (AD, mg/kg-day)	1.3	2.5
	Intermediate (IADD, mg/kg-day)	0.92	1.8
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.85	1.7
Female of Reproductive Age	Dose Rate (APDR, mg/day)	84	167
	Acute (AD, mg/kg-day)	1.2	2.3
	Intermediate (IADD, mg/kg-day)	0.85	1.7
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.78	1.6
ONU	8-hour TWA Exposure Concentration (mg/m^3)	100	100
	Acute Dose (AD) (mg/kg/day)	1.3	1.3
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	0.92	0.92
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg/day)	0.85	0.86
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.12.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-74. Summary of Estimated Worker Aggregate Exposures for Use of Penetrants and Inspection Fluids

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.4	3.2
	Intermediate (IADD, mg/kg-day)	1.1	2.4
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.98	2.2
Female of Reproductive Age	Acute (AD, mg/kg-day)	1.4	3.1
	Intermediate (IADD, mg/kg-day)	1.0	2.3
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.92	2.1
ONU	Acute (AD, mg/kg-day)	1.3	1.3
	Intermediate (IADD, mg/kg-day)	0.93	0.96
	Chronic, Non-Cancer (ADD, mg/kg-day)	0.85	0.89
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.13 Fabrication or Use of Final Product or Articles

3.13.1 Process Description

EPA anticipates that DBP may be present in a wide array of final articles that are used both commercially and industrially. DBP is used in products such as building and construction materials, flooring materials, furniture, and furnishings (NLM, 2024; U.S. EPA, 2020a). Use cases may include melting articles containing DBP and drilling, cutting, grinding, or otherwise shaping articles containing DBP. EPA did not identify any specific product data to support these uses and the only source that indicated these potential uses was the 2020 CDR report (U.S. EPA, 2020a). Per the above discussion, EPA assumed that most products used in this OES are plastics. As a result, EPA used the DBP concentration from the plastic compounding/converting OESs to represent this OES, with DBP at a concentration ranging from 30 to 45 percent (U.S. EPA, 2021c).

3.13.2 Facility Estimates

EPA did not identify representative site- or chemical-specific operating data for this OES (*i.e.*, facility throughput, number of sites, total production volume, operating days, product concentration), as DBP-containing article use occurs at many disparate industrial and commercial sites, with different operating conditions. Due to a lack of readily available information for this OES, the number of industrial or commercial use sites is unquantifiable and unknown. Total production volume for this OES is also unquantifiable, and EPA assumed that each end use site utilizes a small number of finished articles containing DBP. EPA assumed the number of operating days was 250 days/year with 5 day/week operations and two full weeks of downtime per operating year.

3.13.3 Release Assessment

3.13.3.1 Environmental Release Points

EPA did not quantitatively assess environmental releases for this OES due to the lack of process-specific and DBP-specific data; however, EPA expects releases from this OES to be small and disperse in comparison to other upstream OES. EPA also expects DBP to be present in small amounts and predominantly remain in the final article, limiting the potential for release. Table 3-75 describes the expected fabrication and use activities that may potentially generate releases. All releases are non-quantifiable due to a lack of process- and product- specific data.

Table 3-75. Release Activities for Fabrication/Use of Final Articles Containing DBP

Release Point	Release Behavior	Release Media
Cutting, Grinding, Shaping, Drilling, Abrading, and Similar Activities	Dust Generation	Fugitive or Stack Air, Water, Incineration, or Landfill
Heating/Plastic Welding Activities	Vapor Generation	Fugitive or Stack Air

3.13.4 Occupational Exposure Assessment

3.13.4.1 Worker Activities

During fabrication and final use of products or articles, worker exposures to DBP may occur via dermal contact while handling and shaping articles containing DBP additives. Worker exposures may also occur via vapor or particulate inhalation during activities such as cutting, grinding, shaping, drilling, and/or abrasive actions that generate particulates from the product. EPA did not identify chemical-specific information on engineering controls and worker PPE used at final product or article formulation or use sites.

ONUs include supervisors, managers, and other employees that may be present in manufacturing or use areas but do not directly handle DBP-containing materials or articles. ONU inhalation exposures may occur when ONUs are present in the manufacturing area during dust generating activities. EPA also assessed dermal exposures from contact with surfaces where dust has been deposited for ONUs.

3.13.4.2 Occupational Inhalation Exposure Results

EPA identified one sample result from a facility melting, shaping, and joining plastics and two inhalation exposure data points from the machine and manual welding of plastic roofing materials that describes worker exposure to vapor (ECB, 2004; Rudel et al., 2001). Both sources received a rating of medium from EPA's systematic review process. With the three discrete data points, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures. To assess the high-end worker exposure to DBP during the fabrication process, EPA used the maximum available value (0.03 mg/m^3). EPA assessed the median of the three available values as the central tendency (0.01 mg/m^3).

EPA expects the primary exposure route, however, to be from particulates generated during activities such as cutting, grinding, drilling, and other abrasive actions. Therefore, EPA estimated worker inhalation exposures during fabrication or use of final products or articles using the PNOR Model as well (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix D.8.

In the model, EPA used a subset of the PNOR Model (U.S. EPA, 2021b) data for facilities with NAICS codes starting with 337 – Furniture and Related Product Manufacturing to estimate final product particulate concentrations in the air. Particulate exposures across end-use industries may occur during trimming, cutting, and/or abrasive actions on the DBP-containing product. EPA used the highest expected concentration of DBP in final products to estimate the concentration of DBP in the particulates. For this OES, EPA identified 45 percent by mass as the highest expected DBP concentration based on the estimated plasticizer concentrations in relevant products given by the Use of Additives in Plastic Compounding Generic Scenario (U.S. EPA, 2021c). The estimated exposures assume that DBP is present in particulates at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA concentration for particulate by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities.

Table 3-76 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposure to DBP during fabrication or use of final products or articles. The high-end and central tendency exposures use 250 days per year as the exposure frequency since the 95th and 50th percentiles of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days. Appendix A describes the approach for estimating AD, IADD, and ADD. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data, information on the PNOR Model parameters used, and assumptions used in the assessment; refer to Appendix F for a reference to this supplemental document.

Table 3-76. Summary of Estimated Worker Inhalation Exposures for Fabrication or Use of Final Products or Articles

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.10	0.84
	Acute Dose (AD) (mg/kg-day)	1.3E−02	0.11
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	9.2E−03	7.7E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	8.6E−03	7.2E−02
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.10	0.84
	Acute Dose (AD) (mg/kg-day)	1.4E−02	0.12
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.0E−02	8.5E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	9.5E−03	7.9E−02
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.10	0.10
	Acute Dose (AD) (mg/kg-day)	1.3E−02	1.3E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	9.2E−03	9.2E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	8.6E−03	8.6E−03

[a] For the monitoring data, with the three discrete data points, EPA could not create a full distribution of monitoring results to estimate central tendency and high-end exposures (ECB, 2004; Rudel et al., 2001). To assess the high-end worker exposure to DBP during the fabrication process, EPA used the maximum available value (0.03 mg/m^3). EPA assessed the median of the three available values as the central tendency (0.01 mg/m^3). Both sources received a rating of medium from EPA's systematic review process. To calculate dust exposure using the PNOR Model, EPA assumed concentration of DBP in fabrication products is equal to estimated DBP concentrations in flexible PVC to estimate the concentration of DBP. EPA multiplied the concentration of DBP with the central tendency and HE estimates of the relevant NAICS code from the PNOR Model to calculate the central tendency and HE estimates for this OES.

3.13.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper PPE or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. The various "Exposure Concentration Types" from Table 3-77 are explained in Appendix A. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure. Table 3-77 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-77. Summary of Estimated Worker Dermal Exposures for Fabrication or Use of Final Product or Articles

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	1.4	2.7
	Acute (AD, mg/kg-day)	1.7E−02	3.4E−02
	Intermediate (IADD, mg/kg-day)	1.2E−02	2.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−02	2.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	1.1	2.3
	Acute (AD, mg/kg-day)	1.6E−02	3.1E−02
	Intermediate (IADD, mg/kg-day)	1.1E−02	2.3E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.1E−02	2.1E−02
ONU	Dose Rate (APDR, mg/day)	1.4	1.4
	Acute Dose (AD) (mg/kg/day)	1.7E−02	1.7E−02
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	1.2E−02	1.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg/day)	1.2E−02	1.2E−02
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm2 for female workers).			

3.13.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-78. Summary of Estimated Worker Aggregate Exposures for Fabrication or Use of Final Product or Articles

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	2.9E−02	0.14
	Intermediate (IADD, mg/kg-day)	2.2E−02	0.10
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.0E−02	0.10
Female of Reproductive Age	Acute (AD, mg/kg-day)	2.9E−02	0.15
	Intermediate (IADD, mg/kg-day)	2.2E−02	0.11
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.0E−02	0.10
ONU	Acute (AD, mg/kg-day)	2.9E−02	2.9E−02
	Intermediate (IADD, mg/kg-day)	2.2E−02	2.2E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.0E−02	2.0E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.14 Recycling

3.14.1 Process Description

In the 2020 CDR, 13 facilities reported that DBP was not recycled (U.S. EPA, 2020a). EPA did not identify information regarding the recycling of products containing DBP but assumed that DBP is primarily recycled industrially in the form of DBP-containing PVC/plastic waste streams. EPA did not identify additional information on PVC/plastic recycling from systematic review. While chemical/feedstock recycling is possible, EPA did not identify any market share data indicating chemical/feedstock recycling processes for DBP-containing waste streams.

The Association of Plastic Recyclers reports that recycled PVC arrives at a typical recycling site tightly baled as crushed finished articles ranging from 240 to 453 kg (APR, 2023). The bales are unloaded into process vessels, where PVC is grinded and separated from non-PVC fractions using electrostatic separation, washing/floatation, or air/jet separation. Following cooling of grinded PVC, the site transfers the product to feedstock storage for use in the plastics compounding or converting lines or loaded into containers for shipment to downstream use sites. Figure 3-15 provides an illustration of the PVC recycling process (U.S. EPA, 2021c).

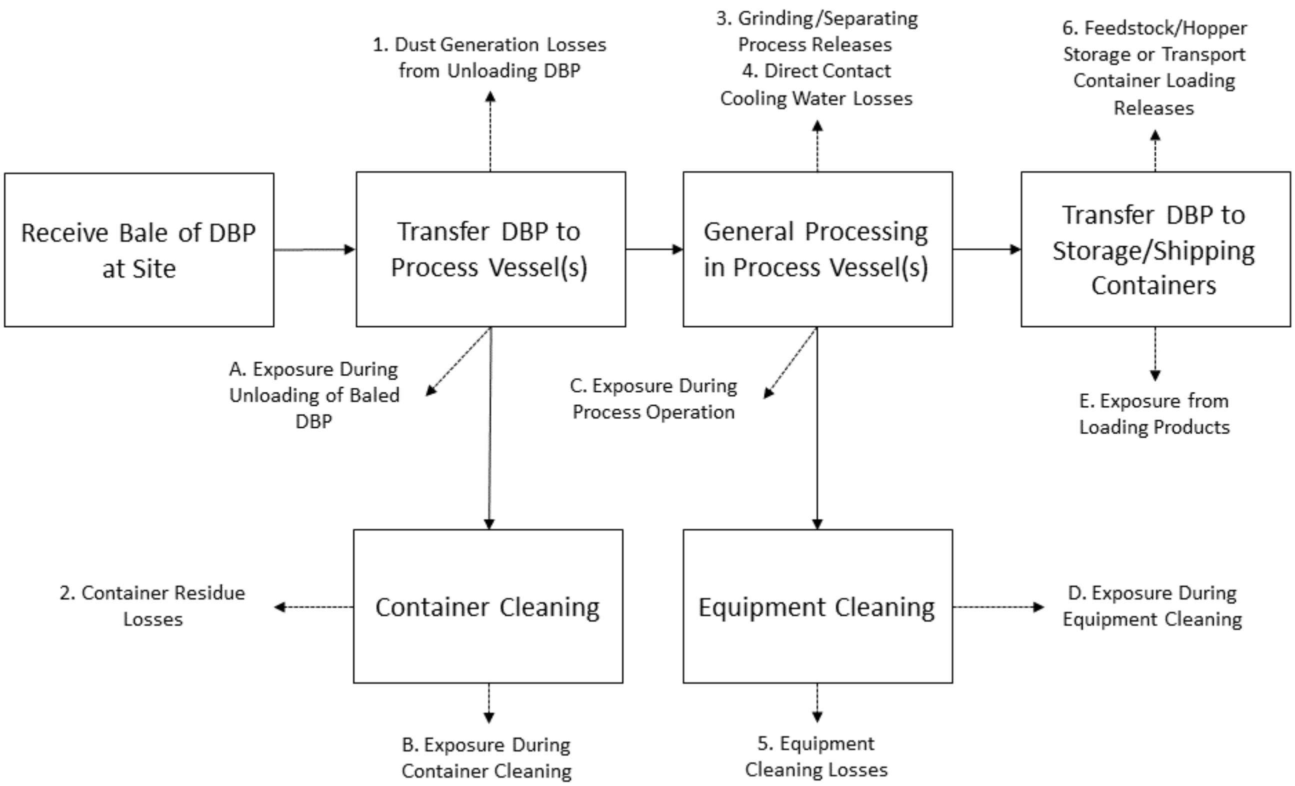


Figure 3-15. PVC Recycling Flow Diagram (U.S. EPA, 2021c)

3.14.2 Facility Estimates

ENF Recycling (ENF Plastic, 2024) estimated a total of 228 plastics recyclers operating in the United States, of which 58 accept PVC wastes for recycling. It is unclear if the total number of sites includes some or all circular recycling sites, which are facilities where new PVC can be manufactured from both recycled and virgin materials. Such sites would be identified primarily by the manufactured product; however, EPA developed site parameters and release estimates for the PVC plastics compounding OES based on generic values specified in the 2021 Generic Scenario on Plastics Compounding, which incorporates all PVC material streams whether from recycled or virgin production (U.S. EPA, 2021c).

EPA was unable to quantify the volume of DBP-containing PVC that is recycled. EPA based volume estimates on data for PVC waste that contained the phthalates Diisononyl Phthalate (DINP) and Diisodecyl Phthalate (DIDP), and scaled these estimates based on overall production volumes for these chemicals in plastic products. The Quantification and Evaluation of Plastic Waste in the United States estimated that of the 699 kilotons of PVC waste managed in 2019, three percent was recycled or 20,970,000 kg of PVC (Milbrandt et al., 2022).

The 2010 technical report on the Evaluation of New Scientific Evidence Concerning DINP and DIDP estimated the fraction of DIDP-containing and DINP-containing PVC used in the overall PVC market as 9.78 percent and 18.3 percent, respectively (ECHA, 2010). As a result, EPA calculated the use rate of recycled PVC plastics containing DBP as 9.78 percent of the yearly recycled production volume of PVC or 2,050,866 kg/year. For DINP the use rate was calculated as 18.3 percent of the yearly recycled production volume of PVC or 3,846,801 kg/year. EPA related the DINP and DIDP information to the production volume of DBP used in plastic products to develop scaling factors for recyclable PVC volumes (see Table 3-79).

Table 3-79. Production Volumes Used to Develop Recycling Estimates

Chemical	Production Volume of Plastic Products (kg/year)	Source
DBP	18,543–222,659	See Section 3.4.2
DINP	64,568,873–473,505,075	(U.S. EPA, 2025c)
DIDP	43,859,857–434,749,009	(U.S. EPA, 2024d)

EPA divided the PV range for DBP by the PV ranges of the other two phthalates to develop scaling factors:

- Low-end scaling factor with DINP data: 18,543 kg/year ÷ 473,505,075 kg/year = 3.92×10^{-5}
- High-end scaling factor with DINP data: 222,659 kg/year ÷ 64,568,873 kg/year = 3.45×10^{-3}
- Low-end scaling factor with DIDP data: 18,543 kg/year ÷ 434,749,009 kg/year = 4.27×10^{-5}
- High-end scaling factor with DIDP data: 222,659 kg/year ÷ 43,859,857 kg/year = 5.08×10^{-3}

EPA then multiplied these scaling factors by the market percentages of the two phthalates in order to estimate a proportional market percentage range for DBP:

- DINP: 0.183 × (3.92×10–5 to 3.45×10^{-3}) = 7.05×10^{-6} to 6.2×10^{-4}
- DIDP: 0.098 × (4.27×10^{-5} to 5.13×10^{-3}) = 4.18×10^{-6} to 5.02×10^{-4}
- Overall range of scaling factors: 4.18×10^{-6} to 6.2×10^{-4}

Based on the 2021 Generic Scenario on Plastics Compounding, EPA estimated that the mass fraction of DBP used as a plasticizer in plastics was 30 to 45 percent (U.S. EPA, 2021c). EPA multiplied the estimated overall PVC waste volume estimate of 20,970,000 kg PVC by the estimated PVC market share for DBP and the fraction of DBP assumed to be used in plastic products. This resulted in a range of 26.3 to 5,857 kg of DBP recycled per year. The GS estimated the total number of operating days of 148 to 264 days/year, with 24 hour/day, 7 day/week (*i.e.*, multiple shifts) operations for the given site throughput scenario (U.S. EPA, 2021c).

3.14.3 Release Assessment

3.14.3.1 Environmental Release Points

No NEI, DMR or TRI data was mapped to this OES. EPA assigned release points for the Recycling OES based on data from the PVC plastics compounding/converting OES for air releases, the Non-PVC material manufacturing OES for land releases, and the PVC plastics compounding OES for water releases. Based on identified details on the recycling process and assumptions from the PVC plastics compounding process, releases to fugitive air, surface water, incineration or landfill may occur from storage or loading of recycled plastic and general recycling processing (U.S. EPA, 2021c). Water, incineration, or landfill releases may occur from container residue losses and equipment cleaning. Surface water releases may occur from direct contact cooling water. Stack air releases may occur from loading recycled plastics into storage and transport containers. Additional fugitive air releases may occur during leakage of pipes, flanges, and accessories used for transport. Due to lack of specific process information at recycling sites, EPA assumed that these sites don’t utilize air pollution capture and control technologies.

3.14.3.2 Environmental Release Assessment Results

Table 3-22, Table 3-23, Table 3-28, Table 3-29, and Table 3-30 provide the air release data from PVC compounding/converting to be applied to the Recycling OES. Table 3-37 provides the land release data from Non-PVC material manufacturing to be applied to the Recycling OES. Table 3-24 provides the water release data from PVC plastics compounding to be applied to the Recycling OES.

3.14.4 Occupational Exposure Assessment

3.14.4.1 Worker Activities

At PVC recycling sites, worker exposures from dermal contact with solids and inhalation of dust may occur during unloading of bailed PVC, loading of PVC onto compounding or converting lines, loading PVC into transport containers, processing recycled PVC, and equipment cleaning (U.S. EPA, 2004a). EPA did not identify information on engineering controls or workers PPE used at recycling sites.

ONUs include supervisors, managers, and other employees that work in the processing area but do not directly handle DBP-containing PVC. ONUs are potentially exposed through the inhalation route while in the working area. EPA also assessed dermal exposures from contact with surfaces where dust has been deposited for ONUs.

3.14.4.2 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data to assess exposures to DBP during recycling processes. Based on the presence of DBP as an additive in plastics (U.S. CPSC, 2015a), EPA assessed worker inhalation exposures to DBP as exposure to particulates of recycled plastic materials. Therefore, EPA estimated worker inhalation exposures during recycling using the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix D.8.

In the model, EPA used a subset of *the* PNOR Model (U.S. EPA, 2021b) data for facilities with the NAICS code starting with 56 – Administrative and Support and Waste Management and Remediation Services to estimate plastic particulate concentrations in the air. EPA used the highest expected concentration of DBP in recyclable plastic products to estimate the concentration of DBP present in particulates. For this OES, EPA identified 45 percent by mass as the highest expected DBP concentration based on the estimated plasticizer concentrations in flexible PVC given by the 2021 Generic Scenario on Plastic Compounding (U.S. EPA, 2021c). The estimated exposures assume that DBP is present in particulates of the plastic at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. In absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure and used this data to generate estimates for ONUs. EPA used the number of operating days estimated in the release assessment for this OES to estimate exposure frequency. The high-end and central tendency exposures use 250 days per year as the exposure frequency since the 95th and 50th percentiles of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days.

Table 3-80 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during recycling. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP in the form of plastic particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis*. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data, information on the PNOR Model parameters used, and assumptions used in the assessment; refer to Appendix F for a reference to this supplemental document.

Table 3-80. Summary of Estimated Worker Inhalation Exposures for Recycling

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.11	1.6
	Acute Dose (AD) (mg/kg-day)	1.4E−02	0.20
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	9.9E−03	0.14
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	9.2E−03	0.13
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.11	1.6
	Acute Dose (AD) (mg/kg-day)	1.5E−02	0.22
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.1E−02	0.16
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.0E−02	0.15
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.11	0.11
	Acute Dose (AD) (mg/kg-day)	1.4E−02	1.4E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	9.9E−03	9.9E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	9.2E−03	9.2E−03

[a] To calculate dust exposure using the PNOR Model, EPA assumed concentration of DBP in recycling products is equal to estimated DBP concentrations in flexible PVC to estimate the concentration of DBP. EPA multiplied the concentration of DBP with the central tendency and HE estimates of the relevant NAICS code from the PNOR Model to calculate the central tendency and HE estimates for this OES.

3.14.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper PPE or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. The various "Exposure Concentration Types" from Table 3-81 are explained in Appendix A. Since there may be dust deposited on surfaces from this OES, EPA assessed dermal exposures to ONUs from contact with dust on surfaces. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure. Table 3-81 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-81. Summary of Estimated Worker Dermal Exposures for Recycling

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
	Dose Rate (APDR, mg/day)	1.4	2.7

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	1.7E−02	3.4E−02
	Intermediate (IADD, mg/kg-day)	1.2E−02	2.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−02	2.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	1.1	2.3
	Acute (AD, mg/kg-day)	1.6E−02	3.1E−02
	Intermediate (IADD, mg/kg-day)	1.1E−02	2.3E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.1E−02	2.1E−02
ONU	8-hour TWA Exposure Concentration (mg/m^3)	1.4	1.4
	Acute Dose (AD) (mg/kg/day)	1.7E−02	1.7E−02
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	1.2E−02	1.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg/day)	1.2E−02	1.2E−02
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.14.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-82. Summary of Estimated Worker Aggregate Exposures for Recycling

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	3.0E−02	0.23
	Intermediate (IADD, mg/kg-day)	2.2E−02	0.17
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.1E−02	0.16
Female of Reproductive Age	Acute (AD, mg/kg-day)	3.0E−02	0.25
	Intermediate (IADD, mg/kg-day)	2.2E−02	0.18
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.1E−02	0.17
ONU	Acute (AD, mg/kg-day)	3.0E−02	3.0E−02
	Intermediate (IADD, mg/kg-day)	2.2E−02	2.2E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.1E−02	2.1E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.15 Waste Handling, Treatment, and Disposal

3.15.1 Process Description

Each of the conditions of use of DBP may generate waste streams of the chemical that are collected and transported to third-party sites for disposal, treatment, or recycling. These waste streams may include the following:

Wastewater

DBP may be contained in wastewater discharged to POTW or other, non-public treatment works for treatment. Industrial wastewater containing DBP discharged to a POTW may be subject to EPA or authorized NPDES state pretreatment programs. An assessment of wastewater discharges to POTWs and non-public treatment works of DBP is included in each of the condition of use assessed in Sections 3.1 through 3.14.

Solid Wastes

Solid wastes are defined under RCRA as any material that is discarded by being abandoned; inherently waste-like; a discarded military munition; or recycled in certain ways (certain instances of the generation and legitimate reclamation of secondary materials are exempted as solid wastes under RCRA). Solid wastes may subsequently meet RCRA's definition of hazardous waste by either being listed as a waste at 40 CFR §§ 261.30 to 261.35 or by meeting waste-like characteristics defined at 40 CFR §§ 261.20 to 261.24. Solid wastes that are hazardous wastes are regulated under the more stringent requirements of Subtitle C of RCRA, whereas non-hazardous solid wastes are regulated under the less stringent requirements of Subtitle D of RCRA. DBP is not listed as a toxic chemical as specified in Subtitle C of RCRA and is not subject to hazardous waste regulations. However, solid wastes containing DBP may require regulation if the waste leaches constituents, specified in the toxicity characteristic leaching procedure (TLCP), in excess of regulatory limits. These constituents could include toxins, such as lead and cadmium, which are used as stabilizers in PVC. An assessment of solid waste discharges of DBP is included in each of the condition of use assessed in Sections 3.1 through 3.14.

EPA expects off-site transfers of DBP and DBP-containing wastes to land disposal, wastewater treatment, incineration, and recycling facilities, based on industry supplied data and published EPA and OECD emission documentation, such as Generic Scenarios and Emission Scenario Documents. Off-site transfers are incinerated, sent to land disposal, sent to wastewater treatment, recycled off-site, or sent to other or unknown off-site disposal/treatment (see Figure 3-16).

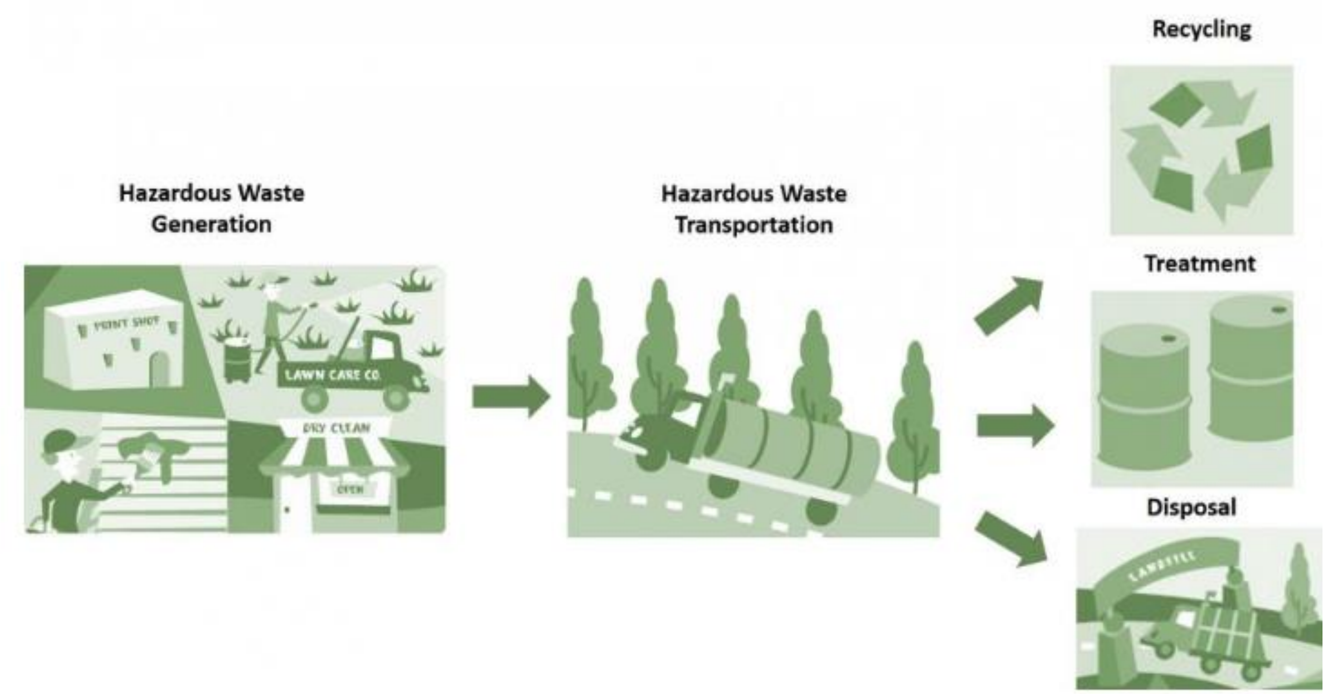


Figure 3-16. Typical Waste Disposal Process
Source: (U.S. EPA, 2017) (https://www.epa.gov/hw/learn-basics-hazardous-waste)

Municipal Waste Incineration

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

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

Tipping floor operations may generate dust. Air from the enclosed tipping floor, however, is continuously drawn into the combustion unit via one or more forced air fans to serve as the primary combustion air and minimize odors. Dust and lint present in the air are typically captured in filters or other cleaning devices to prevent the clogging of steam coils, which are used to heat the combustion air and help dry higher-moisture inputs (Kitto and Stultz, 1992).

Municipal Waste Landfill

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

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

Hazardous Waste Landfill

Hazardous waste landfills are excavated or engineered sites specifically designed for the final disposal of non-liquid hazardous wastes. Design standards for these landfills require double liners, double leachate collection and removal systems, leak detection systems, runoff and wind dispersal controls, and construction quality assurance programs.[2] There are also requirements for closure and post-closure, such as the addition of a final cover over the landfill and continued monitoring and maintenance. These standards and requirements are designed to prevent contamination of groundwater and nearby surface water resources. Hazardous waste landfills are regulated under 40 CFR 264/265, Subpart N.

3.15.2 Facility Estimates

In the NEI (U.S. EPA, 2023a, 2019), DMR (U.S. EPA, 2024a), and TRI (U.S. EPA, 2024e) data that EPA analyzed, EPA identified eight sites that may have used DBP in PVC plastics converting, based on site names and their reported NAICS and SIC codes. Two CDR reporters indicated the use of DBP for Plastics Product Manufacturing in the 2020 CDR. EPA identified operating days ranging from 2-365 with an average of 307 days in the NEI air release data. TRI/DMR (U.S. EPA, 2024a, e) datasets did not report operating days; therefore, EPA used 253 days/year of operation, based on the Revised Plastic Converting GS as discussed in Section 2.3.2 (U.S. EPA, 2014c).

The ESD on Plastic Additives estimates 341 to 3,990 metric tons of flexible PVC produced per site per year (341,000 to 3,990,000 kg/site-year) (OECD, 2009b). A typical number of production days during a year is 148 to 264 days (U.S. EPA, 2014b). Assuming a concentration of DBP in the plastic of 30 to 45 percent (see above) and 264 production days/year, the use rate of DBP is 388 to 12,131 kg/site-day and 102,300 to 1,795,500 kg/site-year.

3.15.3 Release Assessment

3.15.3.1 Environmental Release Assessment Results

EPA assessed environmental releases for this OES based on NEI, TRI, and DMR data. Based this data, waste handling, treatment, and disposal releases may go to fugitive air, stack air, surface water, POTW, landfill, and additional releases may occur from transfers of wastes from off-site treatment facilities (U.S. EPA, 2024a, e, 2023a, 2019).

Table 3-83 presents fugitive and stack air releases per year and per day based on information in the 2017 to 2022 TRI databases, along with the number of release days per year and medians and maxima from across the 6-year reporting range. Table 3-84 presents fugitive and stack air releases per year and per day, based on information in the 2020 NEI database, along with the number of release days per year. Table 3-85 presents fugitive and stack air releases per year and per day, based on information in the 2017 NEI database, along with the number of release days per year. Table 3-86 presents land releases per year based on information in the TRI database along with the number of release days per year. Table 3-87

[2] https://www.epa.gov/hwpermitting/hazardous-waste-management-facilities-and-units

presents water releases per year and per day based on information in the 2017 to 2022 TRI/DMR databases, along with the number of release days per year, with medians and maxima presented from across the 6-year reporting range. The *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP)*, *Draft Summary of Results for Identified Environmental Releases to Land for Dibutyl Phthalate (DBP)*, and *Draft Summary of Results for Identified Environmental Releases to Water for Dibutyl Phthalate (DBP)* contain additional information about these identified releases and their original sources; refer to Appendix F for a reference to these supplemental documents.

Table 3-83. Summary of Air Releases from TRI for Waste Handling, Treatment, and Disposal

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Median Annual Fugitive Air Release (kg/year)	Median Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)	Median Daily Fugitive Air Release (kg/day)	Median Daily Stack Air Release (kg/day)
Clean Harbors Deer Park LLC	4.5E−02	1.06	2.5E−02	4.5E−02	286	3.5E−04	8.1E−03	1.6E−04	3.5E−04
Clean Harbors Aragonite LLC	2.3E−02	0.35	4.5E−03	2.0E−02	286	1.7E−04	2.7E−03	7.1E−05	1.6E−04
Heritage Thermal of Texas LLC	0	9.1E−03	0	9.1E−03	286	0	7.0E−05	3.2E−05	7.0E−05
Buzzi Unicem USA-Cape Girardeau	0.45	0	0.45	0	286	3.5E−03	0	0	0
Eq Detroit Inc	0	738	0	127	286	0	5.69	0.44	0.98
Eco-Services Operations	0	5.0E−02	0	4.5E−02	286	0	3.8E−04	1.6E−04	3.5E−04
Heidelberg Materials Us Cement LLC	0	0	0	0	286	0	0	0	0
Heritage Thermal Services	9.1E−03	0.20	4.5E−03	2.0E−02	286	7.0E−05	1.5E−03	7.1E−05	1.6E−04
Clean Harbors Environmental Services Inc	4.5E−02	162	2.7E−02	43	286	3.5E−04	1.25	0.15	0.34
Clean Harbors El Dorado LLC	4.5E−02	0.98	2.5E−02	9.1E−02	286	3.5E−04	1.3	3.2E−04	7.0E−04
Ross Incineration Services Inc	2.59	0.25	1.8E−02	0	286	2.0E−02	1.9E−03	0	0
EBV Explosives Environmental Co	0	72	0	2.5	286	0	0.56	8.6E−03	1.9E−02
Tradebe Treatment & Recycling LLC	0	0	0	0	286	0	0	0	0
Chemtron Corp	6.6	0	3.4	0	286	5.1E−02	0	0	0
Burlington Environmental LLC	0	0	0	0	286	0	0	0	0
US Army Fort Stewart (Part)	0	0	0	0	286	0	0	0	0
Chemical Waste Management of The Northwest Inc.	0	0	0	0	286	0	0	0	0
Wayne Disposal Inc	7.7E−02	0.14	4.5E−03	5.9E−02	286	5.9E−04	1.1E−03	2.1E−04	4.5E−04
Veolia Es Technical Solutions LLC Port Arthur Facility	1.8	0	1.8	0	286	1.4E−02	0	0	0
US Ecology Michigan Inc.	0	0	0	0	286	0	0	0	0

3976 3977 **Table 3-84. Summary of Air Releases from NEI (2020) for Waste Handling, Treatment, and Disposal**

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Ventura Wastewater Plant	2.1E−03	0	364	5.7E−06	0
Mutual Materials Company	1.35	N/A	286	4.7E−03	N/A
Lakewood Brick & Tile Co	N/A	0	286	N/A	0
Summit Pressed Brick – Brick Mfg Plt	N/A	0	286	N/A	0
General Shale – Denver Brick Plant #60	N/A	0	286	N/A	0
Clean Harbors El Dorado, LLC	4.5E−02	0	286	1.6E−04	0
Meridian Brick LLC	N/A	217	286	N/A	0.76
Meridian Brick LLC	N/A	0.91	286	N/A	3.2E−03
Acme Brick Company	N/A	1.10	286	N/A	3.9E−03
Acme Brick Co – Perla Plant	N/A	0	364	N/A	0
Simi Vly County Sanitation	7.1E−03	0	286	2.5E−05	0
Boral Bricks – Augusta Plants 3, 4, & 5	N/A	0.37	365	N/A	1.0E−03
Howco Environmental Services, Inc.	N/A	5.3E−03	199	N/A	2.7E−05
Salina Mun. Solid Waste Landfill	3.5E−06	N/A	365	9.5E−09	N/A
Glen Gery Corp/Bigler Div	N/A	0	15	N/A	0
Bnz Materials Inc/Zelienople	N/A	0.45	301	N/A	1.5E−03
Kansas Brick & Tile	N/A	0.10	364	N/A	2.9E−04
Elgin Facility	N/A	1.6E−05	365	N/A	4.4E−08
Denton Plant	N/A	0	365	N/A	0
Delta Solid Waste Management Authority	N/A	0	180	N/A	0
Acme Brick Bennett Plant	N/A	0.16	365	N/A	4.4E−04
Oak Grove Landfill	1.3E−05	N/A	364	3.5E−08	N/A
Meridian Brick LLC – Columbia Facility	N/A	160	364	N/A	0.44
Pabco Building Products (F#4070)	1.37	N/A	364	3.8E−03	N/A
Athens Facility	N/A	1.2E−04	365	N/A	3.2E−07
Texas Clay Plant	N/A	0	365	N/A	0
Elgin Plant	N/A	0	365	N/A	0
Glen-Gery Corp/York Division	N/A	0	209	N/A	0
Argos USA – Martinsburg	6.9E−05	0.91	286	2.8E−07	3.7E−03
General Shale Products Inc	N/A	42	286	N/A	0.15
Southbridge Landfill Gas Management	N/A	0	286	N/A	0
RJF – Morin Brick LLC – Auburn	N/A	5.4E−03	286	N/A	1.9E−05
Mineral Wells Facility	N/A	0	365	N/A	0
HRSD Boat Harbor Sewage Treatment Plant	3.5E−02	N/A	286	1.2E−04	N/A

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Meridian Brick LLC – Stanton Plant	N/A	0	286	N/A	0
Redland Brick	N/A	406	260	N/A	1.56
EQ Detroit, Inc. (Dba US Ecology – Detroit South)	N/A	0	286	N/A	0
Continental Brick – Martinsburg Facility	1.72	N/A	220	7.8E−03	N/A
Bowerston Shale Company (0145000010)	N/A	0	365	N/A	0
Sealy Plant	N/A	0	365	N/A	0
40 Acre Facility	9.1E−02	N/A	365	2.5E−04	N/A
Hazardous Waste Disposal	N/A	0.57	365	N/A	1.5E−03
Clean Harbors Deer Park	4.5E−02	0	286	1.6E−04	0
City Of Midland Utilities Division	N/A	0	162	N/A	0
Glen-Gery Corporation – Harmar Plant	N/A	0	230	N/A	0
Clinton County Solid W/Wayne Twp Ldfl	N/A	0	365	N/A	0
Mutual Materials	N/A	0	364	N/A	0
Watsontown Brick Co/Watsontown Plt	N/A	1.4E−03	365	N/A	3.9E−06
Outagamie County Landfill	N/A	0	260	N/A	0
MMSD-Jones Island Water Reclamation Facility	N/A	0	286	N/A	0
Carson City Block Plant	N/A	0	286	N/A	0
Henry Brick Company, Inc.	N/A	0	286	N/A	0
JS&H	N/A	0	286	N/A	0
Redland Brick	N/A	0	286	N/A	0
EBV Explosives Environmental Co Joplin	N/A	0	286	N/A	0
River Cement Co. Dba Buzzi Unicem Usa Selma Plant	N/A	5.3E−03	286	N/A	1.8E−05
Ash Grove Cement Co	N/A	0	286	N/A	0
Central Valley Water Reclamation Facility Wastewater Treatment Plant	N/A	1.09	112	N/A	9.7E−03
Belden Brick Plant 3 (0679005018)	N/A	0	356	N/A	0
Harbisonwalker International, Inc.	N/A	60	286	N/A	0.21
Harbisonwalker International, Inc. (1667090000)	N/A	0	364	N/A	0
Resco Products Inc (1576000771)	N/A	3.0E−04	365	N/A	8.3E−07
Mcavoy Vitrified Brick Co/Phoenixville	N/A	0	214	N/A	0
Clean Harbors Aragonite LLC: Hazardous Waste Storage Incineration	N/A	69	302	N/A	0.23
Lone Star Industries Inc	N/A	0	286	N/A	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Glen-Gery Corp. Iberia Plant (0351000051)	N/A	0	282	N/A	0
Interstate Brick Company: Brick Manufacturing Plant	N/A	4.7E−05	365	N/A	1.3E−07
Mineral Wells East Facility	N/A	3.26	365	N/A	8.9E−03
Lehigh Cement Company – Mason City	N/A	0	315	N/A	0
Clean Harbors Env Services Inc	56	4.5E−04	365	0.15	1.2E−06
Triangle Brick Company – Wadesboro Brick Manufacturing Plant	N/A	0	364	N/A	0
Chemung County Landfill	4.6E−06	N/A	286	1.6E−08	N/A
Tri-State Brick LLC	N/A	2.6E−05	286	N/A	9.0E−08
Endicott Clay Products Co	N/A	0	364	N/A	0
USB Tennessee LLC – Gleason	N/A	3.63	286	N/A	1.3E−02
Meridian Brick, LLC Bessemer Plant No. 6	N/A	0	286	N/A	0
General Shale Brick, Inc. – Moncure Facility	N/A	4.71	260	N/A	1.8E−02
Meridian Brick LLC – Salisbury Facility	N/A	207	364	N/A	0.57
Wewoka Plant	1.85	0	365	5.1E−03	0
Whitacre-Greer (0250000005)	N/A	0	365	N/A	0
Statesville Brick Company	N/A	62	364	N/A	0.17
Lee Brick And Tile Company, Inc.	N/A	22	364	N/A	6.1E−02
Ironrock Capital, Inc. (1576051149)	N/A	0	365	N/A	0
Continental Cement Company – Davenport Plant	N/A	0.53	364	N/A	1.4E−03
Cloud Ceramics	N/A	6.80	364	N/A	1.9E−02
Muskogee Plant	N/A	16	260	N/A	6.3E−02
Hebron Brick Company – Hebron Brick Plant	N/A	48	286	N/A	0.17
Atlantic County Utilities Authority Landfill	N/A	0	286	N/A	0
Lafarge Building Materials Inc	N/A	0.45	286	N/A	1.6E−03
Holcim (Us) Inc. Dba Lafarge Alpena Plant	N/A	1.8E−06	317	N/A	5.7E−09
Ross Incineration Services, Inc. (0247050278)	1.8E−03	N/A	286	6.3E−06	N/A
St Marys Cement Charlevoix Plant	N/A	0	365	N/A	0
3M – Cottage Grove – Corporate Incinerator	6.9E−07	34	286	2.4E−09	0.12

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Lehigh Cement Company – Union Bridge	N/A	0	260	N/A	0
Glen-Gery Corp	N/A	0	286	N/A	0
Harbisonwalker International, Inc Fulton Brick Plant	N/A	9.07	286	N/A	3.2E−02
Harbison-Walker International, Inc. Vandalia Plant	N/A	9.0E−02	286	N/A	3.2E−04
Glen Gery Corp/Mid Atlantic Plt	N/A	0.10	363	N/A	2.8E−04
Meridian Brick	N/A	0	365	N/A	0
Columbus Brick Company Inc	N/A	15	286	N/A	5.3E−02
Bowerston Shale Company (0634000012)	N/A	0	365	N/A	0
Glen Gery Corp/Hanley Plant	N/A	3.6E−02	365	N/A	9.9E−05
Palmetto Brick	N/A	551	365	N/A	1.51
Fulton County Mud Rd Sanitary Landfill	1.1E−04	N/A	286	3.9E−07	N/A
Pine Hall Brick Co., Inc.	N/A	0.46	364	N/A	1.3E−03
Owensboro Brick LLC	N/A	12	286	N/A	4.0E−02
Triangle Brick Company-Merry Oaks Brick Manufacturing Plant	N/A	23	364	N/A	6.2E−02
Summitville Tiles, Inc. – Minerva Plant (0210000047)	N/A	0	365	N/A	0
Olmsted County Waste-To-Energy Facility	N/A	0	286	N/A	0
Madison County Landfill	5.9E−05	N/A	286	2.0E−07	N/A
Glen Gery Corporation (0351000005)	N/A	0	277	N/A	0
Clinton County Regional Landfill	3.1E−05	N/A	286	1.1E−07	N/A
The Belden Brick Company (0679000118)	N/A	0	365	N/A	0
Ava Landfill	N/A	3.72	286	N/A	1.3E−02
Acme Brick Company	N/A	7.80	286	N/A	2.7E−02
General Shale Brick, Inc. – Plant 40	N/A	0	365	N/A	0
Heritage Thermal Services (0215020233)	4.5E−03	0	286	1.6E−05	0
Knight Material Technologies, LLC (1576001851)	N/A	0	365	N/A	0
Hunter Ferrell Landfill	9.9E−07	N/A	2.50	3.9E−07	N/A
Brampton Brick	N/A	0	286	N/A	0
Golden Triangle Regional Solid Waste Man	1.4E−05	N/A	286	4.8E−08	N/A
Rock Oil Refining Inc	N/A	0	286	N/A	0

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Chemical Waste Management of The Northwest, Inc.	N/A	0	286	N/A	0
Dba RB Recycling, Inc.	N/A	0	286	N/A	0

Table 3-85. Summary of Air Releases from NEI (2017) for Waste Handling, Treatment, and Disposal

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Harbison Walker (Fairfield)	N/A	0	286	N/A	0
Taylor Clay Products, Inc.	N/A	11	286	N/A	3.7E−02
Deffenbaugh Ind. – Johnson Co. Landfill	N/A	0	286	N/A	0
Meridian Brick LLC Columbia Facility	N/A	0	286	N/A	0
Richards Brick Co	N/A	0	286	N/A	0
Wayne Disposal Inc	9.1E−03	66	286	3.2E−05	0.23
Met Council – Seneca WWTP	51	223	286	0.18	0.78
Redland Brick Inc/Harmar Plt	N/A	0.59	286	N/A	2.0E−03
Turnkey Recycling & Environmental Enterp	N/A	0	286	N/A	0
Wheelabrator Concord Company LP	N/A	0	286	N/A	0
Central Valley Water Reclamation Fac.: Wastewater Treatment Plant	4.3E−05	0	286	1.5E−07	0
North American Refractories	N/A	9.80	286	N/A	3.4E−02
Sioux City Brick & Tile Company	N/A	0	286	N/A	0
St. Marys Cement Inc	N/A	50	286	N/A	0.17
Holcim Us Inc	N/A	0	286	N/A	0
Meridian Brick LLC – Gleason Plant	N/A	0	286	N/A	0
NYC-Dep Owls Head WPCP	N/A	3.66	286	N/A	1.3E−02
Forterra Brick, LLC – Roseboro Facility	N/A	2.06	286	N/A	7.2E−03
Muskogee Plt	N/A	0	286	N/A	0
General Shale Brick, Inc. – Kings Mountain Facility	N/A	0	286	N/A	0
Illinois Cement Co	N/A	27	286	N/A	9.6E−02

Site Identity	Maximum Annual Fugitive Air Release (kg/year)	Maximum Annual Stack Air Release (kg/year)	Annual Release Days (days/year)	Maximum Daily Fugitive Air Release (kg/day)	Maximum Daily Stack Air Release (kg/day)
Lehigh Cement Company LLC	0	28	286	0	0.10
Acme Brick – Kanopolis	N/A	0	286	N/A	0
Forterra Brick East, LLC – Monroe Facility	N/A	0	286	N/A	0
Olmsted Waste-To-Energy Facility	N/A	6.64	286	N/A	2.3E−02
Florida Brick & Clay Co	N/A	149	286	N/A	0.52
Koch Knight, LLC (1576001851)	N/A	47	286	N/A	0.16
Golden Triangle Regional Solid Waste Management Authority	N/A	0	286	N/A	0
Sand Draw Landfill	N/A	0.16	286	N/A	5.5E−04

Table 3-86. Summary of Land Releases from TRI for Waste Handling, Treatment, and Disposal

Site Identity	Median Annual Release (kg/year)	Maximum Annual Release (kg/year)	Annual Release Days (days/year)
Chemtron Corp	1.3E04	1.9E04	286
Ross Incineration Services Inc	1.3E−02	2.5E−02	286
Tradebe Treatment & Recycling LLC	5,065	5,218	286
Wayne Disposal Inc	4,460	6.8E04	286
Us Ecology Michigan Inc.	1.7E04	1.7E04	286
Eq Detroit Inc	2.7E04	7.4E04	286
Clean Harbors Environmental Services Inc	511	1,537	286
Clean Harbors El Dorado LLC	1.8	4.7	286
Clean Harbors Deer Park LLC	1.4	35	286
Clean Harbors Aragonite LLC	9.7	29	286
Chemical Waste Management of The Northwest Inc.	1.3E04	1.7E04	286
Burlington Environmental LLC	1.3E04	1.3E04	286

Table 3-87. Summary of Water Releases from DMR/TRI for Waste Handling, Treatment, and Disposal

Site Identity	Source-Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Calleguas Mwd Lake Bard Water Plant	DMR	1.3E−03	4.6E−06	1.3E−03	4.6E−06	286

Site Identity	Source-Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Claude “Bud” Lewis Carlsbad Desalination Plant	DMR	0.18	6.4E−04	0.18	6.4E−04	286
Clean Harbors White Castle, LLC – White Castle Landfarm	DMR	8.5	3.0E−02	8.5	3.0E−02	286
Edward C. Little WRP	DMR	2.6	9.0E−03	2.6	9.0E−03	286
Eq Detroit Inc	TRI Form R – Transfer to POTW	0.18	6.3E−04	0.18	6.3E−04	286
Juanita Millender – Mcdonald Carson Regional WRP	DMR	0.19	6.5E−04	0.19	6.5E−04	286
Kahala Hotel & Resort	DMR	33	0.11	33	0.11	286
Lake Of The Pines WWTP	DMR	2.5	8.7E−03	2.5	8.7E−03	286
Malakoff Diggins State Park	DMR	1.1E−02	3.9E−05	0.36	1.3E−03	286
Neewc Seawater Desalination Test Facility	DMR	9.3E−02	3.3E−04	9.3E−02	3.3E−04	286
San Simeon Acres WWTF	DMR	1.4	5.0E−03	1.4	5.0E−03	286
SPX Cooling Technologies	DMR	4.2E−03	1.5E−05	4.2E−03	1.5E−05	286
Us Natl Park Service Yosemite Natl Park	DMR	5.6E−02	1.9E−04	7.2E−02	2.5E−04	286
Aliso Creek Ocean Outfall	DMR	4.9	1.7E−02	4.9	1.7E−02	286
Anchor Bay WWTF	DMR	5.0E−04	1.7E−06	5.0E−04	1.7E−06	286
Anderson Wastewater Treatment Plant	DMR	3.5E−02	1.2E−04	3.5E−02	1.2E−04	286
Arizona City Sanitary District – WWTP	DMR	1.1	3.7E−03	1.3	4.6E−03	286
Avalon WWTP	DMR	0.15	5.2E−04	0.16	5.6E−04	286
Barbourville STP	DMR	18	6.2E−02	18	6.2E−02	286
Brawley Wastewater Treatment Plant	DMR	3.4E−02	1.2E−04	4.2E−02	1.5E−04	286
Brentwood Wastewater Treatment Plant	DMR	1.5	5.2E−03	1.5	5.2E−03	286
Burlingame WWTP	DMR	41	0.14	41	0.14	286
Calipatria WWTP	DMR	6.8E−02	2.4E−04	6.8E−02	2.4E−04	286
Cascade Shores WWTP	DMR	0.62	2.2E−03	0.62	2.2E−03	286
Cayucos Sanitary District WRRF	DMR	6.2E−02	2.2E−04	6.2E−02	2.2E−04	286

Site Identity	Source-Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Charlotte WWTP	DMR	0.36	1.2E−03	0.36	1.2E−03	286
City Of Alturas Wastewater Treatment Plant	DMR	0.14	4.8E−04	0.14	4.8E−04	286
City Of Daly City--A-Street Pump Station	DMR	334	1.2	334	1.2	286
City Of Red Bluff Wastewater Reclamation Plant	DMR	2.1	7.2E−03	4.0	1.4E−02	286
City Of Safford – Gila Resources WRP	DMR	5.7	2.0E−02	5.7	2.0E−02	286
Clear Creek WWTP	DMR	1.1	3.8E−03	1.1	3.8E−03	286
Clovis Sewage Treatment and Water Reuse Facility	DMR	0.34	1.2E−03	0.34	1.2E−03	286
Colusa WWTP	DMR	0.18	6.3E−04	0.18	6.3E−04	286
Corning Wastewater Treatment Plant	DMR	3.6E−02	1.3E−04	3.6E−02	1.3E−04	286
Corona WWTP 1	DMR	17	6.1E−02	23	8.2E−02	286
Fallbrook Pud WWTP No.1	DMR	0.12	4.3E−04	0.12	4.3E−04	286
Fallon Wastewater Treatment Plant	DMR	1.1	3.7E−03	1.1	3.7E−03	286
Fort Bragg WWTF	DMR	4.6	1.6E−02	6.1	2.1E−02	286
Grosse Ile Twp WWTP	DMR	12	4.3E−02	38	0.13	286
Guthrie STP	DMR	3.3	1.2E−02	3.3	1.2E−02	286
Healdsburg WWTF	DMR	2.6	9.0E−03	2.6	9.0E−03	286
Lake Wildwood WWTP	DMR	12	4.3E−02	12	4.3E−02	286
Manteca WWQCF	DMR	8.8	3.1E−02	8.7	3.1E−02	286
Middlesex County Utilities Authority	DMR	35	0.12	69	0.24	286
Montecito Sd WWTP	DMR	0.18	6.4E−04	0.18	6.4E−04	286
Monterey Regional WWTP	DMR	0.45	1.6E−03	1.5	5.4E−03	286
Mt. Shasta WWTP	DMR	1.4E−02	4.9E−05	1.4E−02	4.9E−05	286
Northern Edge Casino	DMR	0.28	9.7E−04	0.28	9.7E−04	286
Northern Madison County Sanitation District	DMR	1.4	4.9E−03	1.4	4.9E−03	286
Northwest WWTF	DMR	7.3E−02	2.5E−04	7.3E−02	2.5E−04	286
Olivehurst WWTF	DMR	45	0.16	45	0.16	286

Site Identity	Source-Discharge Type	Median Annual Discharge (kg/year)	Median Daily Discharge (kg/day)	Maximum Annual Discharge (kg/year)	Maximum Daily Discharge (kg/day)	Annual Release Days (days/year)
Orange County Sanitation District Plant 1	DMR	12	4.3E−02	19	6.8E−02	286
Oxnard Wastewater Treatment Plant (OWTP)	DMR	11	3.8E−02	11	3.8E−02	286
Pima County – Ina Road WWTP	DMR	76	0.27	76	0.27	286
Richmond Otter Creek STP	DMR	69	0.24	69	0.24	286
Richmond Silver Creek STP	DMR	6.4	2.2E−02	13	4.5E−02	286
Rio Vista WWTF	DMR	0.11	3.9E−04	0.11	3.9E−04	286
San Elijo WPCF	DMR	7.2	2.5E−02	19	6.6E−02	286
Santa Cruz Wastewater Treatment Plant	DMR	0.80	2.8E−03	11	3.9E−02	286
Sd City Pt Loma Wastewater Treatment	DMR	63	0.22	79	0.28	286
Sewer Authority Mid-Coastside	DMR	24	8.5E−02	24	8.5E−02	286
South Bay International WWTP	DMR	17	5.9E−02	55	0.19	286
South San Francisco-San Bruno	DMR	417	1.5	417	1.5	286
South San Luis Obispo Sd WWTP	DMR	1.2	4.1E−03	1.2	4.1E−03	286
Summerland Sd WWTP	DMR	0.10	3.4E−04	0.10	3.4E−04	286
Town Of Red River	DMR	2,742	9.6	5,324	19	286
Tuba City WWTP	DMR	2.5	8.7E−03	2.5	8.7E−03	286
Willows WWTP	DMR	4.6E−02	1.6E−04	4.6E−02	1.6E−04	286
Woodland WPCF	DMR	0.57	2.0E−03	0.65	2.3E−03	286
Honeywell, Inc., Formerly Alliedsignal	DMR	8.5E−02	3.0E−04	8.5E−02	3.0E−04	286

3.15.4 Occupational Exposure Assessment

3.15.4.1 Worker Activities

At waste disposal sites, workers are potentially exposed via dermal contact with waste containing DBP or via inhalation of DBP vapor or dust. Depending on the concentration of DBP in the waste stream, the route and level of exposure may be similar to that associated with container unloading activities.

Municipal Waste Incineration

At municipal waste incineration facilities, there may be one or more technicians present on the tipping floor to oversee operations, direct trucks, inspect incoming waste, or perform other tasks as warranted by individual facility practices. These workers may wear protective gear such as gloves, safety glasses, or dust masks. Specific worker protocols are largely up to individual companies, although state or local regulations may specify worker safety standards. Federal operator training requirements pertain more to the operation of the regulated combustion unit rather than operator health and safety.

Workers are potentially exposed via inhalation of vapors and dust while working on the tipping floor. Potentially exposed workers include workers stationed on the tipping floor, including front-end loader operators, crane operators, and truck drivers. The potential for dermal exposures is minimized by the use of trucks and cranes to handle the wastes.

Hazardous Waste Incineration

EPA did not identify information on the potential for worker exposures during hazardous waste incineration or for any requirements for personal protective equipment. There is likely a greater potential for worker exposures for smaller scale incinerators that involve more direct handling of the wastes.

Municipal and Hazardous Waste Landfill

At landfills, typical worker activities include operating refuse vehicles to weigh and unload the waste materials, operating bulldozers to spread and compact wastes, and monitoring, inspecting, and surveying and landfill site.[3]

3.15.4.2 Occupational Inhalation Exposure Results

EPA did not identify inhalation monitoring data to assess exposures to DBP during disposal processes. Based on the presence of DBP as an additive in plastics (U.S. CPSC, 2015a), EPA assessed worker inhalation exposures to DBP as an exposure to particulates of discarded plastic materials. Therefore, EPA estimated worker inhalation exposures during disposal using the PNOR Model (U.S. EPA, 2021b). Model approaches and parameters are described in Appendix D.8.

In the model, EPA used a subset of the PNOR Model (U.S. EPA, 2021b) data that came from facilities with the NAICS code starting with 56 – Administrative and Support and Waste Management and Remediation Services to estimate plastic particulate concentrations in the air. EPA used the highest expected concentration of DBP in plastic products to estimate the concentration of DBP present in particulates. For this OES, EPA identified 45 percent by mass as the highest expected DBP concentration based on the estimated plasticizer concentrations in flexible PVC given by the 2021 Generic Scenario on Plastic Compounding (U.S. EPA, 2021c). The estimated exposures assume that DBP is present in particulates of the plastic at this fixed concentration throughout the working shift.

The PNOR Model (U.S. EPA, 2021b) estimates an 8-hour TWA for particulate concentrations by assuming exposures outside the sample duration are zero. The model does not determine exposures during individual worker activities. Due to expected process similarities, EPA used the number of operating days estimated in the release assessment for the recycling OES to estimate exposure frequency. The high-end and central tendency exposures use 250 days per year as the exposure frequency since the 95th and 50th percentiles of operating days in the release assessment exceeded 250 days per year, which is the expected maximum number of working days.

Table 3-88 summarizes the estimated 8-hour TWA concentration, AD, IADD, and ADD for worker exposures to DBP during disposal. Appendix A describes the approach for estimating AD, IADD, and ADD. The estimated exposures assume that the worker is exposed to DBP in the form of plastic

[3] http://www.calrecycle.ca.gov/SWfacilities/landfills/needfor/Operations.htm,

particulates and does not account for other potential inhalation exposure routes, such as from the inhalation of vapors, which EPA expects to be *de minimis*. The *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP)* contains further information on the identified inhalation exposure data, information on the PNOR Model parameters used, and assumptions used in the assessment; refer to Appendix F for a reference to this supplemental document.

Table 3-88. Summary of Estimated Worker Inhalation Exposures for Disposal

Modeled Scenario	Exposure Concentration Type	Central Tendency[a]	High-End[a]
Average Adult Worker	8-hour TWA Exposure Concentration (mg/m^3)	0.11	1.6
	Acute Dose (AD) (mg/kg-day)	1.4E−02	0.20
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	9.9E−03	0.14
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	9.2E−03	0.13
Female of Reproductive Age	8-hour TWA Exposure Concentration (mg/m^3)	0.11	1.6
	Acute Dose (AD) (mg/kg-day)	1.5E−02	0.22
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	1.1E−02	0.16
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	1.0E−02	0.15
ONU	8-hour TWA Exposure Concentration (mg/m^3)	0.11	0.11
	Acute Dose (AD) (mg/kg-day)	1.4E−02	1.4E−02
	Intermediate Non-Cancer Exposures (IADD) (mg/kg-day)	9.9E−03	9.9E−03
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg-day)	9.2E−03	9.2E−03

[a] To calculate dust exposure using the PNOR Model, EPA assumed concentration of DBP in disposal products is equal to estimated DBP concentrations in flexible PVC to estimate the concentration of DBP. EPA multiplied the concentration of DBP with the central tendency and HE estimates of the relevant NAICS code from the PNOR Model to calculate the central tendency and HE estimates for this OES.

3.15.4.3 Occupational Dermal Exposure Results

EPA estimated dermal exposures for this OES using the dermal approach outlined in Section 2.4.3 and Appendix C. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper PPE or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. The various "Exposure Concentration Types" from Table 3-89 are explained in Appendix A. Since there may be dust deposited on surfaces from this OES, dermal exposures to ONUs from contact with dust on surfaces were assessed. In the absence of data specific to ONU exposure, EPA assumed that worker central tendency exposure was representative of ONU exposure. Table 3-89 summarizes the APDR, AD, IADD, and ADD for average adult workers, female workers of reproductive age, and ONUs. The *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)* also contains information about model equations and parameters and contains calculation results; refer to Appendix F for a reference to this supplemental document.

Table 3-89. Summary of Estimated Worker Dermal Exposures for Disposal

Modeled Scenario	Exposure Concentration Type	Central Tendency	High-End
Average Adult Worker	Dose Rate (APDR, mg/day)	1.4	2.7
	Acute (AD, mg/kg-day)	1.7E−02	3.4E−02
	Intermediate (IADD, mg/kg-day)	1.2E−02	2.5E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.2E−02	2.3E−02
Female of Reproductive Age	Dose Rate (APDR, mg/day)	1.1	2.3
	Acute (AD, mg/kg-day)	1.6E−02	3.1E−02
	Intermediate (IADD, mg/kg-day)	1.1E−02	2.3E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	1.1E−02	2.1E−02
ONU	Dose Rate (APDR, mg/day)	1.4	1.4
	Acute Dose (AD) (mg/kg/day)	1.7E−02	1.7E−02
	Intermediate Average Daily Dose, Non-Cancer Exposures (IADD) (mg/m^3)	1.2E−02	1.2E−02
	Chronic Average Daily Dose, Non-Cancer Exposures (ADD) (mg/kg/day)	1.2E−02	1.2E−02
Note: For high-end estimates, EPA assumed the exposure surface area was equivalent to mean values for two-hand surface areas (*i.e.*, 1,070 cm^2 for male workers and 890 cm^2 for female workers) (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).			

3.15.4.4 Occupational Aggregate Exposure Results

Inhalation and dermal exposure estimates were aggregated based on the approach described in Appendix A.3 to arrive at the aggregate worker and ONU exposure estimates in the table below. The assumption behind this approach is that an individual worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.

Table 3-90. Summary of Estimated Worker Aggregate Exposures for Disposal

Modeled Scenario	Exposure Concentration Type (mg/kg-day)	Central Tendency	High-End
Average Adult Worker	Acute (AD, mg/kg-day)	3.0E−02	0.23
	Intermediate (IADD, mg/kg-day)	2.2E−02	0.17
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.1E−02	0.16
Female of Reproductive Age	Intermediate (IADD, mg/kg-day)	3.0E−02	0.25
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.2E−02	0.18
	Chronic, Cancer (LADD, mg/kg-day)	2.1E−02	0.17
ONU	Acute (AD, mg/kg-day)	3.0E−02	3.0E−02
	Chronic, Non-Cancer (ADD, mg/kg-day)	2.2E−02	2.2E−02
	Chronic, Cancer (LADD, mg/kg-day)	2.1E−02	2.1E−02
Note: A worker could be exposed by both the inhalation and dermal routes, and the aggregate exposure is the sum of these exposures.			

3.16 Distribution in Commerce

3.16.1 Process Description

For purposes of assessment in this risk evaluation, distribution in commerce consists of the transportation associated with the moving of DBP or DBP-containing products and/or articles between sites manufacturing, processing, and use COUs, or the transportation of DBP containing wastes to recycling sites or for final disposal. EPA expects all the DBP or DBP-containing products and/or articles to be transported in closed system or otherwise to be transported in a form (*e.g.*, articles containing DBP) such that there is negligible potential for releases except during an incident. Therefore, no occupational exposures are reasonably expected to occur, and no separate assessment was performed for estimating releases and exposures from distribution in commerce.

4 WEIGHT OF SCIENTIFIC EVIDENCE CONCLUSIONS

4.1 Environmental Releases

For each OES, EPA considered the assessment approach; the quality of the data and models; and the strengths, limitations, assumptions, and key sources of uncertainties in the assessment results to determine a weight of the scientific evidence rating. EPA considered factors that increase or decrease the strength of the evidence supporting the release estimate (*e.g.*, quality of the data/information), the applicability of the release or exposure data to the OES (*e.g.*, temporal relevance, locational relevance), and the representativeness of the estimate for the whole industry. EPA used the descriptors of robust, moderate, slight, or indeterminant to categorize the available scientific evidence using its best professional judgment, according to EPA's *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2021a). EPA used slight to describe limited information that does not sufficiently cover all sites within the OES, and for which the assumptions and uncertainties are not fully known or documented. See EPA's *Application of Systematic Review in TSCA Risk Evaluations* (U.S. EPA, 2021a) for additional information on weight of the scientific evidence conclusions. Release data was primarily sourced from 2017 to 2022 TRI (U.S. EPA, 2024e), 2017 and 2020 NEI (U.S. EPA, 2023a, 2019), and DMR (U.S. EPA, 2024a). NEI data has a high data quality rating from EPA's systematic review process; TRI and DMR have high data quality ratings.

Table 4-1 and Table 4-2 provide a summary of EPA's overall weight of scientific evidence conclusions in its environmental release estimates for each OES.

Table 4-1. Summary of the Data Sources Used for Environmental Releases by OES

OES	Release Media	Reported Data[a]	Data Quality Ratings for Reported Data[b]	Modeling	Data Quality Ratings for Modeling[c]	Weight of Scientific Evidence Conclusion
Manufacturing	Fugitive air	×	N/A	✓	M	Moderate
	Stack air	×	N/A	✓	M	
	Water, incineration, or landfill	×	N/A	✓	M	
Import and repackaging	Water	✓	M–H	×	N/A	Moderate to Robust
	Fugitive air	✓	M–H	×	N/A	
	Stack air	✓	M–H	×	N/A	
	Land	✓	M–H	×	N/A	
Incorporation into formulation, mixture, or reaction product	Water	✓	M–H	×	N/A	Moderate to Robust
	Fugitive air	✓	M–H	×	N/A	
	Stack air	✓	M–H	×	N/A	
	Land	✓	M–H	×	N/A	
PVC plastics compounding	Water	✓	M–H	×	N/A	Moderate to Robust (Air and Water) Moderate (Land)
	Fugitive air	✓	M–H	×	N/A	
	Stack air	✓	M–H	×	N/A	
	Land	✓	M–H	×	N/A	
PVC plastics converting	Water	✓	M–H	×	N/A	Moderate to Robust (Air) Moderate (Land and Water)
	Fugitive air	✓	M–H	×	N/A	
	Stack air	✓	M–H	×	N/A	
	Land	✓	M–H	×	N/A	
Non-PVC plastic manufacturing (compounding and converting)	Water	✓	M–H	×	N/A	Moderate to Robust
	Fugitive air	✓	M–H	×	N/A	
	Stack air	✓	M–H	×	N/A	
	Land	✓	M–H	×	N/A	
Application of adhesives and sealants	Water	×	N/A	✓	M	Moderate to Robust (Air)
	Fugitive air	✓	M–H	×	N/A	

OES	Release Media	Reported Data[a]	Data Quality Ratings for Reported Data[b]	Modeling	Data Quality Ratings for Modeling[c]	Weight of Scientific Evidence Conclusion
	Stack air	✓	M–H	×	N/A	Moderate (Land and Water)
	Land	×	N/A	✓	M	
Application of paints and coatings	Water	×	N/A	✓	M	Moderate to Robust (Air) Moderate (Land and Water)
	Fugitive air	✓	M–H	×	N/A	
	Stack air	✓	M–H	×	N/A	
	Incineration or landfill	×	N/A	✓	M	
	Water, incineration, or landfill	×	N/A	✓	M	
	Unknown (air, water, incineration, or landfill)	×	N/A	✓	M	
Industrial process solvent use	Water	×	N/A	×	N/A	Moderate to Robust (Air) Moderate (Land)
	Fugitive air	✓	M–H	×	N/A	
	Stack air	✓	M–H	×	N/A	
	Land	✓	M–H	×	N/A	
Use of laboratory chemicals (liquid)	Fugitive air	✓	H	×	N/A	Moderate to Robust (Air) Moderate (Land and Water)
	Water, incineration, or landfill	×	N/A	✓	M	
Use of laboratory chemicals (solid)	Fugitive air	✓	H	✓	M	Moderate to Robust (Air) Moderate (Land and Water)
	Incineration or landfill	×	N/A	✓	M	
	Water, incineration, or landfill	×	N/A	✓	M	
	Unknown media (air, water, incineration, or landfill)	×	N/A	✓	M	
	Unknown (air, water, incineration, or landfill)	×	N/A	✓	M	
Use of lubricants and functional fluids	Land	×	N/A	✓	M	Moderate
	Water	×	N/A	✓	M	
	Recycling	×	N/A	✓	M	

OES	Release Media	Reported Data[a]	Data Quality Ratings for Reported Data[b]	Modeling	Data Quality Ratings for Modeling[c]	Weight of Scientific Evidence Conclusion
	Fuel blending (incineration)	✗	N/A	✓	M	
Use of penetrants and inspection fluids	Fugitive air	✗	N/A	✓	M	Moderate
	Water, incineration, or landfill	✗	N/A	✓	M	
Fabrication or use of final product or articles	No data were available to estimate releases for this OES and there were no suitable surrogate release data or models. This release is described qualitatively.					
Recycling	Water	✓	M–H	✗	N/A	Moderate
	Fugitive air	✓	M–H	✗	N/A	
	Stack air	✓	M–H	✗	N/A	
	Land	✓	M–H	✗	N/A	
Waste handling, treatment, and disposal	Water	✓	M–H	✗	N/A	Moderate to Robust
	Fugitive air	✓	M–H	✗	N/A	
	Stack air	✓	M–H	✗	N/A	
	Land	✓	M–H	✗	N/A	

[a] Reported data includes data obtained from EPA databases (*i.e.*, TRI, NEI, DMR).
[b] Data quality ratings for reported data are based on EPA systematic review and include ratings Low (L), Medium (M), and High (H)
[c] 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.

Table 4-2. Summary of Assumptions, Uncertainty, and Overall Weight of Scientific Evidence Conclusions in Release Estimates by OES

OES	Weight of Scientific Evidence Conclusion in Release Estimates
Manufacturing	EPA found limited chemical specific data for the manufacturing OES and assessed environmental releases using models and model parameters derived from CDR, the 2023 *Methodology for Estimating Environmental Releases from Sampling Wastes* (U.S. EPA, 2023c), and sources identified through systematic review (including surrogate—DINP and DIDP—industry-supplied data). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, with media of release assessed using appropriate default input parameters from EPA/OPPT models and industry supplied data. EPA believes a strength of the Monte Carlo modeling approach is that variation in model input values allow for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Additionally, Monte Carlo modeling uses a large number of data points (simulation runs) and considers the full distributions of input parameters. EPA used facility-specific DBP manufacturing volumes for all facilities that reported this information to CDR. For facilities that did not report DBP manufacturing volumes to CDR, operating parameters were derived using data from a current U.S. manufacturing site for DIDP and DINP that is assumed to operate using similar operating parameters as DBP manufacturing. This information was used to provide more accurate estimates than the generic values provided by the EPA/OPPT models. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of release estimates toward the true distribution of potential releases. In addition, one DBP manufacturing site and two manufacturing and/or import sites claimed their DBP production volume as CBI for the purpose of CDR reporting; therefore, DBP throughput estimates for these sites are based on the national aggregate PV and reported import volumes from other sites. Additional limitations include uncertainties in the representativeness of the surrogate industry-provided operating parameters from DIDP and DINP and the generic EPA/OPPT models used to calculate environmental releases for DBP manufacturing sites. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several uncertainties discussed above, such as using surrogate parameters, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate, considering the strengths and limitations of the reasonably available data.
Import and repackaging	Air releases are assessed using reported releases from 2017–2022 TRI (U.S. EPA, 2024e), and 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. The air releases assessment is based on 10 reporting sites in NEI and 4 reporting sites in TRI. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, DMR, etc.), there may be 14 additional repackaging sites that we do not have reported releases for this media in this assessment. Land releases are assessed using reported releases from 2017–2022 TRI. The primary limitation is that the land releases assessment is based on two reporting sites (two sites only reported air releases), and EPA did not have additional sources to estimate land releases from this OES. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, DMR, NEI, etc.), there may be 26 additional repackaging sites that do not have reported releases for this media in this assessment.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	Water releases are assessed using reported releases from 2017–2022 TRI and DMR. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. The primary limitation is that the water release assessment is based on one reporting site under DMR and four reporting sites in TRI (two sites only reported air releases), and EPA did not have additional sources to estimate water releases from this OES. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, NEI, etc.), there may be 23 additional repackaging sites that do not have reported releases for this media in this assessment. As discussed above, the strength of the analysis includes using industry reported release data to various EPA databases. However, several uncertainties discussed above, such as not capturing all release sources, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering the strengths and limitations of reasonably available data.
Incorporation into formulations, mixtures, and reaction products	Air releases are assessed using reported releases from 2017–2022 TRI (U.S. EPA, 2024e), and 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). The primary strength of TRI data is that TRI compiles the data reported directly by facilities that manufacture, process, and/or use DBP. NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. The air releases assessment is based on 32 reporting sites under NEI and 18 reporting sites in TRI (two sites reported under both TRI and NEI). Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, DMR, etc.), there may be two additional incorporation into formulation, mixture, or reaction product sites that do not have reported releases for this media in this assessment. The relatively large number of reporting sites is a strength for these release estimates as they add variability to the assessment and as a result are more likely to be representative of the industry as a whole. Land releases are assessed using reported releases from 2017–2022 TRI. The primary limitation is that the land releases assessment is based on three reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, DMR, NEI, etc.), there may be 47 additional incorporation into formulation, mixture, or reaction product sites that do not have reported releases for this media in this assessment. Water releases are assessed using reported releases from 2017–2022 TRI. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, the limitations in representativeness to all sites because TRI may not capture all relevant sites, and EPA did not have additional sources to estimate water releases from this OES. The water releases assessment is based on 11 reporting sites in TRI. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, NEI, etc.), there may be 39 additional incorporation into formulation, mixture, or reaction product sites that do not have reported releases for this media in this assessment. As discussed above, the strength of the analysis includes using industry reported release data to various EPA databases. However, several uncertainties discussed above, such as not capturing all release sources, slightly reduced the confidence of the analysis.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering the strengths and limitations of reasonably available data.
PVC plastics compounding	Air releases are assessed using reported releases from 2017–2022 TRI (U.S. EPA, 2024e), and 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). The primary strength of TRI data is that TRI compiles the data reported directly by facilities that manufacture, process, and/or use DBP. NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. The air releases assessment is based on one reporting site under NEI and one reporting site in TRI. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, DMR, etc.), there may be 15 additional PVC plastics compounding sites that do not have reported releases for this media in this assessment. TRI reporters identified for this OES reported zero releases for land; however, it is uncertain if that is representative for PVC compounding sites as a whole. Because of this, EPA assessed land releases using surrogate data from sites that were identified under the OES for non-PVC materials manufacturing. Releases were estimated using reported releases from 2017–2022 TRI. The primary limitation is that the land releases assessment is based on three reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Water releases are assessed using reported releases from to DMR (U.S. EPA, 2024a). The primary strength of DMR data is that it may capture additional sources that are not included in TRI due to reporting thresholds. A factor that decreases the overall confidence for this OES include the uncertainty in the accuracy of reported releases. The water releases assessment is based on 14 reporting sites. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, NEI, etc.), there may be three PVC plastics compounding sites that do not have reported releases for this media in this assessment. As discussed above, the strength of the analysis includes using industry reported release data to various EPA databases. However, several uncertainties discussed above, such as not capturing all release sources, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering the strengths and limitations of reasonably available data.
PVC plastics converting	Air releases are assessed using reported releases from 2017–2022 TRI (U.S. EPA, 2024e), and 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). The primary strength of TRI data is that TRI compiles the data reported directly by facilities that manufacture, process, and/or use DBP. NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. The air releases assessment is based on seven reporting sites under NEI and one reporting site in TRI. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, DMR, etc.), there may be two additional PVC plastics converting sites that do not have reported releases for this media in this assessment.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	EPA did not identify land release data from TRI reporters for this OES. These releases were assessed using surrogate data from sites that were identified under the OES for non-PVC materials manufacturing due to expected similarities in the processes that occur at the sites. Releases were estimated using reported releases from 2017–2022 TRI. The primary limitation is that the land releases assessment is based on three reporting sites, and EPA did not have additional sources to estimate land releases from this OES. EPA did not identify water release data from TRI and DMR reporters for this OES. These releases are assessed using surrogate data from sites that were identified under the OES for PVC plastics compounding due to expected similarities in the processes that occur at the sites. Water releases are assessed using reported releases from to DMR (U.S. EPA, 2024a). The primary strength of DMR data is that it may capture additional sources that are not included in TRI due to reporting thresholds. A factor that decreases the overall confidence for this OES include the uncertainty in the accuracy of reported releases. The water releases assessment is based on 14 reporting sites. As discussed above, the strength of the analysis includes using industry reported release data to various EPA databases. However, several uncertainties discussed above, such as not capturing all release sources, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering the strengths and limitations of reasonably available data.
Non-PVC material manufacturing	Air releases are assessed using reported releases from 2017–2022 TRI (U.S. EPA, 2024e), and 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. The air releases assessment is based on 49 reporting sites under NEI and 4 reporting sites in TRI (one site reported under both TRI and NEI). The relatively large number of reporting sites is a strength for these release estimates as they add variability to the assessment and as a result are more likely to be representative of the industry as a whole. Land releases are assessed using reported releases from 2017–2022 TRI. The primary limitation is that the land releases assessment is based on three reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, DMR, NEI, etc.), there may be 49 additional non PVC-material manufacturing sites that do not have reported releases for this media in this assessment. Water releases are assessed using reported releases from 2017–2022 TRI. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, the limitations in representativeness to all sites because TRI may not capture all relevant sites, and EPA did not have additional sources to estimate water releases from this OES. The water releases assessment is based on 1 reporting site in TRI. Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, NEI, etc.), there may be 51 additional sites that do not have reported releases for this media in this assessment.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	As discussed above, the strength of the analysis includes using industry reported release data to various EPA databases. However, several uncertainties discussed above, such as not capturing all release sources, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering the strengths and limitations of reasonably available data.
Application of adhesives and sealants	Air releases are assessed using reported releases from 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). NEI captures additional sources that are not included in TRI due to reporting thresholds. Another factor that increases the strength of the data is that air release data was provided by 166 reporting sites, which adds variability to the assessment. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, the fact that the type of end-use product is uncertain between adhesives/sealants and paint/coatings, and the limitations in representativeness to all sites because NEI may not capture all relevant sites. EPA was unable to identify chemical and site-specific releases to land and water and assessed these releases using the ESD on the Use of Adhesives (OECD, 2015). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using appropriate default input parameters from the ESD and EPA/OPPT models. EPA believes a strength of the Monte Carlo modeling approach is that variation in model input values allow for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DBP-specific data on concentration and application methods for different DBP-containing adhesives and sealant products in the analysis. These data provide more accurate estimates than the generic values provided by the ESD. These strengths increase the weight of evidence. The primary limitation of EPA's approach to land and water releases is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD may not represent releases from real-world sites that incorporate DBP into adhesives and sealants. Based on the number of formulated products identified, the overall production volume of DBP for this OES was estimated by assuming that the portion of DBP with uncertain end-use will be split between adhesives/sealants and paint/coating products. EPA lacks data on DBP-specific facility use volume and number of use sites; therefore, EPA based facility throughput estimates and number of sites on industry-specific default facility throughputs from the ESD, DBP product concentrations, and the overall production volume range from CDR data which has a reporting threshold of 25,000 lb. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using industry reported release data to various EPA databases. However, several uncertainties discussed above, such as not capturing all release sources, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering the strengths and limitations of reasonably available data.
Application of paints and coatings	Air releases are assessed using reported releases from 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). NEI captures additional sources that are not included in TRI due to reporting thresholds. Another factor that increases the strength of the data is that air release data was provided by 166 reporting sites, which adds variability to the assessment. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, the fact that the type of end-use product is uncertain between

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	adhesives/sealants and paint/coatings, and the limitations in representativeness to all sites because NEI may not capture all relevant sites. EPA was unable to identify chemical and site-specific releases to land and water and assessed these releases using the ESD on the Application of Radiation Curable Coatings, Inks and Adhesives and the GS on Coating Application via Spray Painting in the Automotive Refinishing Industry (OECD, 2011a, b). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment. EPA assessed media of release using appropriate default input parameters from the ESD, GS, and EPA/OPPT models and a default assumption that all paints and coatings are applied via spray application. EPA believes a strength of the Monte Carlo modeling approach is that variation in model input values allow for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. Additionally, EPA used DBP-specific data on concentration for different DBP-containing paints and coatings in the analysis. These data provide more accurate estimates than the generic values provided by the GS and ESD. These strengths increase the weight of evidence. The primary limitation of EPA's approach to land and water releases is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the GS and ESD may not represent releases from real-world sites that incorporate DBP into paints and coatings. Additionally, EPA assumes spray applications of the coatings, which may not be representative of other coating application methods. In addition, EPA lacks data on DBP-specific facility use volume and number of use sites; therefore, EPA based throughput estimates on values from ESD, GS, and CDR data which has a reporting threshold of 25,000 lb and an annual DBP production volume range. Finally, EPA estimated the overall production volume of DBP for this OES by assuming that the portion of DBP with uncertain end-use will be split between adhesives/sealants and paint/coating products. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using industry reported release data to NEI and using Monte Carlo modeling which can use range as an input. However, several uncertainties discussed above, such as the unavailability of reported releases for land and water, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering of the strengths and limitations of reasonably available data.
Industrial process solvent use	Air releases are assessed using reported releases from 2017–2022 TRI (U.S. EPA, 2024e), and 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. The air releases assessment is based on two reporting sites under NEI and one reporting site in TRI (site reported under both TRI and NEI). Based on the NAICS and SIC codes used to map data from the reporting databases (CDR, DMR, etc.), there may be one additional industrial process solvent use site that is not accounted for in this assessment. EPA was unable to identify land release data from TRI reporters for this OES. These releases were assessed using surrogate data from sites that were identified under the OES for incorporation into formulation, mixtures, or reaction products due to expected

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	similarities in the processes that occur at the sites. Land releases were estimated using reported releases from 2017–2022 TRI. The primary limitation is that the land releases assessment is based on three reporting sites, and EPA did not have additional sources to estimate land releases from this OES. EPA was unable to identify water release data from TRI and DMR reporters for this OES; however, based on the specifics of DBP's use in the process, EPA does not expect water releases for this OES. This is based on process information provided by Huntsman Corporation, which was rated high in systematic review (Huntsman, 2015). As discussed above, the strength of the analysis includes using industry reported release data to various EPA databases. However, several uncertainties discussed above, such as not capturing all release sources or using surrogate reported releases, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering of the strengths and limitations of reasonably available data.
Use of laboratory chemicals	Air releases are assessed using reported releases from 2017 and 2020 NEI (U.S. EPA, 2023a, 2019). NEI captures additional sources that are not included in TRI due to reporting thresholds. NEI data was collected from two reporting sites. Factors that decrease the overall confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because NEI may not capture all relevant sites. EPA were unable to identify chemical and site-specific releases to land and water and assessed these releases using the Draft GS on the Use of laboratory chemicals (U.S. EPA, 2023d). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using appropriate default input parameters from the GS and EPA/OPPT models for solid and liquid DBP materials. EPA believes a strength of the Monte Carlo modeling approach is that variation in model input values allow for estimation of a range of potential release values that are more likely to capture actual releases than a discrete value. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. EPA used SDSs from identified laboratory DBP products to inform product concentration and material states. These strengths increase the weight of evidence. EPA believes the primary limitation of the land and water release assessments to be the uncertainty in the representativeness of values toward the true distribution of potential releases. In addition, EPA lacks data on DBP-specific laboratory chemical throughput and number of laboratories; therefore, EPA based the number of laboratories and throughput estimates on stock solution throughputs from the Draft GS on the Use of laboratory chemicals and on CDR reporting thresholds. Additionally, because no entries in CDR indicate a laboratory use and there were no other sources to estimate the volume of DBP used in this OES, EPA developed a high-end bounding estimate based on the CDR reporting threshold of 25,000 lb or 5 percent of total product volume for a given use, which by definition is expected to over-estimate the average release case. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using industry reported release data to NEI and using Monte Carlo modeling which can use range as an input. However, several uncertainties discussed above, such as the unavailability of reported

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	releases for land and water, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering of the strengths and limitations of reasonably available data.
Use of lubricants and functional fluids	EPA found limited chemical specific data for the use of lubricants and functional fluids OES and assessed releases to the environment using the ESD on the Lubricant and Lubricant Additives. EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using appropriate default input parameters from the ESD and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. EPA did not identify a lubricant or functional fluid product that contained DBP but identified one DINP-containing functional fluid for use in Monte Carlo analysis for the Risk Evaluation for that chemical. Therefore, EPA used products containing DINP as surrogate for concentration and use data in the analysis. This data provides more accurate estimates than the generic values provided by the ESD. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD may not represent releases from real-world sites using DBP-containing lubricants and functional fluids. In addition, EPA lacks information on the specific facility use rate of DBP-containing products and number of use sites; therefore, EPA estimated the number of sites and throughputs based on CDR, which has a reporting threshold of 25,000 lb (*i.e.*, not all potential sites represented), and an annual DBP production volume range that spans an order of magnitude. The respective share of DBP use for each OES presented in the EU Risk Assessment Report may differ from actual conditions adding some uncertainty to estimated releases. Furthermore, EPA lacks chemical-specific information on concentrations of DBP in lubricants and functional fluids and primarily relied on surrogate data. Actual concentrations may differ adding some uncertainty to estimated releases. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several uncertainties discussed above, such as the lack of availability of reported releases, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate, considering the strengths and limitations of the reasonably available data.
Use of penetrants and inspection fluids	EPA found limited chemical specific data for the use of penetrants and inspection fluids OES and assessed releases to the environment using the ESD on the Use of Metalworking Fluids (OECD, 2011c). EPA used EPA/OPPT models combined with Monte Carlo modeling to estimate releases to the environment, and media of release using appropriate default input parameters from the ESD, and EPA/OPPT models. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also consider a large number of data points (simulation runs) and the full distributions of input parameters. EPA assessed an aerosol and non-aerosol application method based on surrogate DINP-specific penetrant data which also provided DINP concentration. The safety and product data sheets that EPA used to obtain these values provide more accurate estimates than the generic values provided by the ESD.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
	The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values in the ESD and the surrogate material parameters may not be representative of releases from real-world sites that use DBP-containing inspection fluids and penetrants. Additionally, because no entries in CDR indicate this OES use case and there were no other sources to estimate the volume of DBP used in this OES, EPA developed a high-end bounding estimate based on CDR reporting threshold, which by definition is expected to overestimate the average release case. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several uncertainties discussed above, such as the lack of availability of reported releases, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate, considering the strengths and limitations of the reasonably available data.
Fabrication or use of final product or articles	No data were available to estimate releases for this OES and there were no suitable surrogate release data or models. This release is described qualitatively.
Recycling	EPA found limited chemical specific data for the recycling OES. EPA assessed releases to the environment from recycling activities using the Revised Draft GS for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c) as surrogate for the recycling process. EPA/OPPT models were combined with Monte Carlo modeling to estimate releases to the environment. EPA believes the strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential release values are more likely to capture actual releases than discrete values. Monte Carlo modeling also considers a large number of data points (simulation runs) and the full distributions of input parameters. EPA referenced the Quantification and evaluation of plastic waste in the United States (Milbrandt et al., 2022), to estimate the rate of PVC recycling in the U.S. EPA estimated the DBP PVC market share (based on the surrogate market shares from DINP and DIDP) to define an approximate recycling volume of PVC containing DBP. These strengths increase the weight of evidence. The primary limitation of EPA's approach is the uncertainty in the representativeness of estimated release values toward the true distribution of potential releases at all sites in this OES. Specifically, the generic default values and release points in the GS represent all types of plastic compounding sites and may not represent sites that recycle PVC products containing DBP. In addition, EPA lacks DBP-specific PVC recycling rates and facility production volume data; therefore, EPA based throughput estimates on PVC plastics compounding data and U.S. PVC recycling rates, which are not specific to DBP, and may not accurately reflect current U.S. recycling volume. DBP may also be present in non-PVC plastics that are recycled; however, EPA was unable to identify information on these recycling practices. These limitations decrease the weight of evidence. As discussed above, the strength of the analysis includes using Monte Carlo modeling, which can use a range as an input, increases confidence in the analysis. However, several uncertainties discussed above, such as the lack of availability of reported releases, reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate, considering the strengths and limitations of the reasonably available data.

OES	Weight of Scientific Evidence Conclusion in Release Estimates
Waste handling, treatment, and disposal	***General Waste Handling, Treatment, and Disposal*** Air releases for non-POTW sites are assessed using reported releases from 2017–2022 TRI, and 2017 and 2020 NEI. NEI captures additional sources that are not included in TRI due to reporting thresholds. Factors that decrease the confidence for this OES include the uncertainty in the accuracy of reported releases, and the limitations in representativeness to all sites because TRI and NEI may not capture all relevant sites. The air release assessment is based on 147 sites under NEI and 20 sites in TRI (with 9 sites reporting under both NEI and TRI). Based on other reporting databases (CDR, DMR, etc), there are 12 additional non-POTW sites that do not have reported releases for this media in this assessment. Land releases for non-POTW are assessed using reported releases from 2017–2022 TRI. The primary limitation is that the land releases assessment is based on 12 reporting sites, and EPA did not have additional sources to estimate land releases from this OES. Based on the reporting databases (CDR, DMR, NEI, etc.), there are 214 additional waste handling, treatment, and disposal sites that do not have reported releases for this media in this assessment. Water releases for non-POTW sites are assessed using reported releases from 2017–2022 TRI and DMR. The primary strength of TRI data is that TRI compiles the best readily available release data for all reporting facilities. For non-POTW sites, the primary limitation is that the water release assessment is based on 13 reporting sites under DMR and one reporting site in TRI, and EPA did not have additional sources to estimate water releases from this OES. Based on other reporting databases (CDR, NEI, etc), there are 156 additional sites that do not have reported releases for this media in this assessment. As discussed above, the strength of the analysis includes using industry reported release data to various EPA databases. However, several uncertainties discussed above, such as not capturing all release sources, slightly reduced the confidence of the analysis. Therefore, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust, considering the strengths and limitations of reasonably available data. ***Waste Handling, Treatment, and Disposal (POTW and Remediation)*** Water releases for POTW and remediation sites are assessed using reported releases from 2017–2022 DMR, which has a high overall data quality determination from the systematic review process. A strength of using DMR data and the Pollutant Loading Tool used to pull the DMR data is that the tool calculates an annual pollutant load by integrating monitoring period release reports provided to the EPA and extrapolating over the course of the year. However, this approach assumes average quantities, concentrations, and hydrologic flows for a given period are representative of other times of the year. A total of 57 POTW/remediation sites reported releases of DBP to DMR. Based on this information, for POTW releases, EPA has concluded that the weight of scientific evidence for this assessment is moderate to robust, considering the strengths and limitations of reasonably available data.

4.2 Occupational Exposures

Judgment on the weight of scientific evidence is based on the strengths, limitations, and uncertainties associated with the exposure estimates. The Agency considers factors that increase or decrease the strength of the evidence supporting the exposure estimate—including quality of the data/information, applicability of the exposure data to the COU (including considerations of temporal and locational relevance) and the representativeness of the estimate for the whole industry. The best professional judgment is summarized using the descriptors of robust, moderate, slight, or indeterminant, in accordance with the *Draft Systematic Review Protocol Supporting TSCA Risk Evaluations for Chemical Substances, Version 1.0: A Generic TSCA Systematic Review Protocol with Chemical-Specific Methodologies* (also called "Draft Systematic Review Protocol") (U.S. EPA, 2021a). For example, a conclusion of moderate weight of scientific evidence is appropriate where there is measured exposure data from a limited number of sources, such that there is a limited number of data points that may not be representative of worker activities or potential exposures. A conclusion of slight weight of scientific evidence is appropriate where there is limited information that does not sufficiently cover all potential exposures within the COU, and the assumptions and uncertainties are not fully known or documented. See the Draft Systematic Review Protocol (U.S. EPA, 2021a) for additional information on weight of scientific evidence conclusions.

Table 4-3 provides a summary of EPA's overall confidence in its occupational exposure estimates for each of the OESs assessed.

4135 **Table 4-3. Summary of Assumptions, Uncertainty, and Overall Confidence in Inhalation Exposure Estimates by OES**

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
Manufacturing	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the full-shift TWA inhalation exposure estimates for the Manufacturing OES. The primary strength of this approach is the use of directly applicable monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of occupational exposure limits (OELs). EPA used personal breathing zone (PBZ) air concentration data pulled from three sources to assess inhalation exposures (ECB, 2008, 2004; SRC, 2001). All three data sources received a rating of medium from EPA's systematic review process. These data were DBP-specific, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include the uncertainty of the representativeness of these data toward the true distribution of inhalation concentrations for this scenario. Additionally, the dataset is only built on limited data points (3 data source) with a significant spread of measurements. The SRC source cites an ACC study that provides a datapoint as a worst-case scenario, the ECJRC, 2008 source only provides a single datapoint with uncertain statistics and the ECJRC, 2004 source provided a dataset with an uncertain range and number of samples. EPA also assumed eight exposure hours per day and 250 exposure days per year based on continuous DBP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Although the use of monitoring data specific to this OES increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust.
Import and repackaging	EPA used surrogate monitoring data from DBP manufacturing facilities to estimate worker inhalation exposures, due to no relevant OES-specific data availability for import and repackaging inhalation exposures. The primary strength of this approach is the use of monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of OELs. EPA used personal breathing zone (PBZ) air concentration data pulled from three sources to assess inhalation exposures (ECB, 2008, 2004; SRC, 2001). All three data sources received a rating of medium from EPA's systematic review process. These data were DBP-specific, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include uncertainty in the representativeness of these data for this OES and true distribution of inhalation concentrations in this scenario. Additionally, the dataset is only built on limited data points (3 data source) with a significant spread of measurements. The SRC source cites an ACC study that provides a datapoint as a worst-case scenario, the ECJRC, 2008 source only provides a single datapoint with uncertain statistics and the ECJRC, 2004 source provided a dataset with an uncertain range and number of samples. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DBP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Although the use of surrogate monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
Incorporation into formulations, mixtures, or reaction products	EPA used surrogate monitoring data from DBP manufacturing facilities to estimate worker inhalation exposures, due to no data availability for Incorporation into formulations, mixtures, or reaction products (adhesives, coatings, and other) inhalation exposures. The primary strength of this approach is the use of monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of OELs. EPA used personal breathing zone (PBZ) air concentration data pulled from three sources to assess inhalation exposures (ECB, 2008, 2004; SRC, 2001). All three data sources received a rating of medium from EPA's systematic review process. These data were DBP-specific, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include uncertainty in the representativeness of these data for this OES and the true distribution of inhalation concentrations in this scenario. Additionally, the dataset is only built on limited data points (3 data source) with a significant spread of measurements. The SRC source cites an ACC study that provides a datapoint as a worst-case scenario, the ECJRC, 2008 source only provides a single datapoint with uncertain statistics and the ECJRC, 2004 source provided a dataset with an uncertain range and number of samples. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DBP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Although the use of surrogate monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate.
PVC plastics compounding	EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for PVC plastics compounding. EPA used surrogate monitoring data from a PVC converting facility to estimate worker inhalation exposures due to no relevant OES-specific data. The primary strength of this approach is the use of monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of occupational exposure limits (OELs). EPA used personal breathing zone (PBZ) air concentration data pulled from one source to assess inhalation exposures to vapor. This source provided worker exposures from two different studies (ECB, 2004) and received a rating of medium from EPA's systematic review process. EPA also expects compounding activities to generate dust from solid PVC plastic products; therefore, EPA incorporated the PNOR Model (U.S. EPA, 2021b) into the assessment to estimate worker inhalation exposures to solid particulate. A strength of the model is that the respirable PNOR range was refined using OSHA CEHD datasets, which EPA tailored to the Plastics and Rubber Manufacturing NAICS code (NAICS 326), and the resulting dataset contains 237 discrete sample data points (OSHA, 2019). EPA estimated the highest expected concentration of DBP based on the Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c). The primary limitations of these data include uncertainty in the representativeness of the vapor monitoring data and the PNOR Model in capturing the true distribution of inhalation concentrations for this OES. Additionally, the vapor monitoring dataset consisted of just four datapoints for workers, none of the datapoints indicate the worker tasks, and two of the data points are for an unspecified sector of the "polymer industry". Further, the OSHA CEHD dataset used in the PNOR Model is not specific to DBP.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	Finally, EPA assumed 8 exposure hours per day and 250 exposure days per year based on continuous DBP exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Although the use of surrogate monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate.
PVC plastics converting	EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for PVC plastics converting. EPA used personal breathing zone (PBZ) air concentration data pulled from one source to assess inhalation exposures to vapor. The primary strength of this approach is the use of directly applicable monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of occupational exposure limits (OELs). This source provided worker exposures from two different studies (ECB, 2004) and received a rating of medium from EPA's systematic review process. EPA also expects converting activities to generate dust from solid PVC plastic products; therefore, EPA incorporated the PNOR Model (U.S. EPA, 2021b) into the assessment to estimate worker inhalation exposures to solid particulate. A strength of the model is that the respirable PNOR range was refined using OSHA CEHD datasets, which EPA tailored to the Plastics and Rubber Manufacturing NAICS code (NAICS 326) and the resulting dataset contains 237 discrete sample data points (OSHA, 2019). EPA estimated the highest expected concentration of DBP based on the Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c). The primary limitations of these data include uncertainty in the representativeness of the vapor monitoring data and the PNOR Model in capturing the true distribution of inhalation concentrations for this OES. Additionally, the vapor monitoring dataset consisted of just four datapoints for workers, none of the datapoints indicate the worker tasks, and two of the data points are for an unspecified sector of the "polymer industry". Further, the OSHA CEHD dataset used in the PNOR Model is not specific to DBP. Finally, EPA assumed 8 exposure hours per day and 250 exposure days per year based on continuous DBP exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Although the use of monitoring data specific to this OES increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust.
Non-PVC materials compounding and converting	EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for non-PVC materials compounding and converting. EPA used surrogate monitoring data from a PVC converting facility to estimate worker inhalation exposures due to no relevant OES-specific data. The primary strength of this approach is the use of monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of occupational exposure limits (OELs). EPA used personal breathing zone (PBZ) air concentration data pulled from one source to assess inhalation exposures to vapor. This source provided worker exposures from two different studies (ECB, 2004) and received a rating of medium from EPA's systematic review process.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	EPA also expects compounding activities to generate dust from solid PVC plastic products; therefore, EPA incorporated the PNOR Model (U.S. EPA, 2021b) into the assessment to estimate worker inhalation exposures to solid particulate. A strength of the model is that the respirable PNOR range was refined using OSHA CEHD datasets, which EPA tailored to the Plastics and Rubber Manufacturing NAICS code (NAICS 326) and the resulting dataset contains 237 discrete sample data points (OSHA, 2019). EPA estimated the highest expected concentration of DBP based on the Emission Scenario Document on Additives in Rubber Industry (OECD, 2004a). The primary limitations of these data include uncertainty in the representativeness of the vapor monitoring data and the PNOR Model in capturing the true distribution of inhalation concentrations for this OES. Additionally, the vapor monitoring dataset consisted of just four datapoints for workers, none of the datapoints indicate the worker tasks, and two of the data points are for an unspecified sector of the "polymer industry". Further, the OSHA CEHD dataset used in the PNOR Model is not specific to DBP. Finally, EPA assumed 8 exposure hours per day and 250 exposure days per year based on continuous DBP exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Although the use of surrogate monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate.
Application of adhesives and sealants	EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the application of adhesives and sealants. EPA used monitoring data from a NIOSH HHE that documented exposures at a single furniture assembly site to estimate worker inhalation exposures to vapor. The primary strength of this approach is the use of directly applicable monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of occupational exposure limits (OELs). EPA used personal breathing zone (PBZ) air concentration data from this source to assess inhalation exposures (NIOSH, 1977). The source received a rating of medium from EPA's systematic review process. The primary limitations of these data include uncertainty in the representativeness of the vapor monitoring data in capturing the true distribution of inhalation concentrations for this OES. Only one use site type, furniture manufacturing, is represented by the data and this may not represent the entire adhesive and sealant industry. Additionally, 100% of the vapor monitoring datapoints were below the LOD and therefore the actual exposure concentration is unknown with the LOD used as an upper limit of exposure. Finally, EPA assumed 8 exposure hours per day and 232-250 exposure days per year based on continuous DBP exposure during each working day for a typical worker schedule with the exposure days representing the 50th-95th percentile of the exposure day distribution. It is uncertain whether this assumption captures actual worker schedules and exposures. Although the use of monitoring data specific to this OES increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust and provides an upper-bound estimate of exposures.
Application of paints and coatings	EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the application of paints and

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	coatings. EPA identified two full-shift PBZ monitoring samples in OSHA's CEHD and a monitoring dataset from an industry sponsored study found through EPA's literature search. The primary strength of this approach is the use of directly applicable monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of occupational exposure limits (OELs). EPA used personal breathing zone (PBZ) air concentration data from the two sources, which represent three different use facilities, to assess inhalation exposures (OSHA, 2019 Rohm & Haas, 1990, 1332993). The OSHA CEHD source received a rating of high and the Rohm & Haas source received a rating of low from EPA's systematic review process. The primary limitations of these data include uncertainty in the representativeness of the monitoring data in capturing the true distribution of inhalation concentrations for this OES. Three different use sites are represented by the data but these may not represent the overall DBP-containing paint and coating industry. Finally, EPA assumed 8 exposure hours per day and 250 exposure days per year based on continuous DBP exposure during each working day for a typical worker schedule. It is uncertain whether this assumption captures actual worker schedules and exposures. Although the use of monitoring data specific to this OES increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate to robust.
Use of industrial process solvents	EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the Use of industrial process solvents. Due to no relevant OES-specific data, EPA used surrogate monitoring data from DBP manufacturing facilities to estimate worker inhalation exposures. The primary strength of this approach is the use of monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of OELs. EPA used personal breathing zone (PBZ) air concentration data pulled from three sources to assess inhalation exposures (ECB, 2008, 2004; SRC, 2001). All three data sources received a rating of medium from EPA's systematic review process. These data were DBP-specific, though it is uncertain whether the measured concentrations accurately represent the entire industry. The primary limitations of these data include uncertainty in the representativeness of these data for this OES and true distribution of inhalation concentrations in this scenario. Additionally, the dataset is only built on limited data points (3 data source) with a significant spread of measurements. The SRC source sites an ACC conversation that provides a datapoint as a worst-case scenario, the ECJRC, 2008 source only provides a single datapoint with uncertain statistics and the ECJRC, 2004 source provided a dataset with an uncertain range and number of samples. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DBP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Although the use of surrogate monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate.
Use of laboratory chemicals	EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the Use of laboratory chemicals. Due

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	to no relevant OES-specific data, EPA used surrogate monitoring data from a NIOSH HHE for Application of adhesives and sealants OES to estimate worker vapor inhalation exposures, and the PNOR Model (U.S. EPA, 2021b) to characterize worker particulate inhalation exposures. The primary strength of this approach is the use of monitoring data, which are preferrable to other assessment approaches, such as modeling or the use of OELs. EPA used personal breathing zone (PBZ) air concentration data from the NIOSH HHE to assess inhalation exposures (NIOSH, 1977). The source received a rating of medium from EPA's systematic review process. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The model data is based on OSHA CEHD data (OSHA, 2019). EPA used a subset of the respirable particulate data from the generic model identified with the Professional, Scientific, and Technical Services NAICS code (NAICS code 54) to assess this OES, which EPA expects to be the most representative subset of the particulate data for use of laboratory chemicals in the absence of DBP-specific data. EPA estimated the highest expected concentration of DBP in identified DBP-containing products applicable to this OES. The primary limitation of this approach is uncertainty in the representativeness of the vapor monitoring data and the PNOR Model in capturing the true distribution of inhalation concentrations for this OES. Additionally, the vapor monitoring data come from one source where the identified samples were below the LOD and therefore the actual exposure concentration is unknown with the LOD used as an upper limit of exposure. Further, the OSHA CEHD dataset used in the PNOR Model is not specific to DBP. EPA also assumed 8 exposure hours per day and 250 exposure days per year based on continuous DBP exposure each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. Although the use of surrogate monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate and provides an upper-bound estimate of exposures.
Use of lubricants and functional fluids	EPA considered the assessment approach, the quality of the data, and the uncertainties in the assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates for the Use of lubricants and functional fluids. Due to no relevant OES-specific data, EPA used surrogate monitoring data from the OES for application of adhesives containing DBP to estimate worker vapor inhalation exposures. The primary strength of this approach is the use of monitoring data, which are preferrable to other assessment approaches, such as modeling or the use of OELs. EPA used personal breathing zone (PBZ) air concentration data from this source to assess inhalation exposures (NIOSH, 1977). The source received a rating of medium from EPA's systematic review process. The primary limitation of this approach is uncertainty in the representativeness of the vapor monitoring data in capturing the true distribution of inhalation concentrations for this OES. Additionally, the vapor monitoring data come from one source and 100% of the data were below the LOD. EPA also assumed 8 exposure hours per day and 2 to 4 exposure days per year based on a typical equipment maintenance schedule; it is uncertain whether this captures actual worker schedules and exposures.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	Although the use of surrogate monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA concluded that the weight of scientific evidence for this assessment is moderate and provides an upper-bound estimate of exposures
Use of penetrants and inspection fluids	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the 8-hour TWA inhalation exposure estimates. EPA developed a Penetrant and Inspection Fluid Near-Field/Far-Field Inhalation Exposure Model which uses a near-field/far-field approach and the inputs to the model were derived from references that received ratings of medium-to-high for data quality in the systematic review process. EPA combined this model with Monte Carlo modeling to estimate occupational exposures in the near-field (worker) and far-field (ONU) inhalation exposures. A strength of the Monte Carlo modeling approach is that variation in model input values and a range of potential exposure values is more likely than a discrete value to capture actual exposure at sites, the high number of data points (simulation runs), and the full distributions of input parameters. EPA identified and used a DINP-containing penetrant/inspection fluid product as surrogate to estimate concentrations, application methods, and use rate. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. EPA lacks facility and DBP-specific product use rates, concentrations, and application methods, therefore, estimates are made based on surrogate DINP-containing product. EPA only found one product to represent this use scenario, however, and its representativeness of all DBP-containing penetrants and inspection fluids is not known. Also, EPA based exposure days and operating days as specified in the ESD on the Use of Metalworking Fluids (OECD, 2011c), which may not be representative of all facilities and workers that use these products. Although the use of Monte Carlo modeling increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate.
Fabrication or use of final product and articles	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the full-shift TWA inhalation exposure estimates for the fabrication or use of final products or articles OES. EPA used monitoring data from a facility melting, shaping, and gluing plastics and a facility welding plastic roofing components (ECB, 2004; Rudel et al., 2001) to assess worker inhalation exposures to vapor. Both sources received a rating of medium from EPA's systematic review process. The Agency utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The primary strength of this approach is the use of monitoring data, which is preferrable to other assessment approaches, such as modeling or the use of OELs. For the vapor exposure, EPA used workplace DBP air concentration data found from two sources to assess inhalation exposures to vapor. This data was DBP-specific and from facilities manipulating finished DBP-containing articles. The respirable particulate concentrations used by the generic model is based on OSHA CEHD data (OSHA, 2019). EPA used a subset of the respirable particulate data from the generic model identified with the Furniture and Related Product Manufacturing NAICS code (NAICS code 337) to assess this OES, which EPA expects to be the most representative subset of the particulate data for this OES. EPA estimated the highest expected concentration of DBP in particulates during product fabrication using plasticizer

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	additive concentration information from the Use of Additives in Plastic Converting Generic Scenario (U.S. EPA, 2004a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DBP is uncertain. Further, the model lacks metadata on worker activities. EPA also assumed eight exposure hours per day based on continuous DBP particulate exposure while handling DBP-containing products on site each working day for a typical worker schedule; it is uncertain whether this captures actual worker schedules and exposures. EPA set the number of exposure days for both central tendency and high-end exposure estimates at 250 days per year based on EPA default assumptions. Vapor exposures are not expected to significantly contribute to overall inhalation exposure compared to particulate exposures. These limitations decrease the weight of evidence. Although the use of monitoring data specific to this OES increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides an upper-bound estimate of exposures.
Recycling	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the full-shift TWA inhalation exposure estimates for the recycling OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model are based on OSHA CEHD data (OSHA, 2019). EPA used a subset of the respirable particulate data from the generic model identified with the Administrative and Support and Waste Management and Remediation Services NAICS code (NAICS code 56) to assess this OES, which EPA expects to be the most representative subset of the particulate data for this OES. EPA estimated the highest expected concentration of DBP in plastic using plasticizer additive concentration information from the Use of Additives in Plastic Converting Generic Scenario (U.S. EPA, 2004a). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DBP is uncertain. Further, the model lacks metadata on worker activities. EPA set the number of exposure days for both central tendency and high-end exposure estimates at 250 days per year based on EPA default assumptions. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. These limitations decrease the weight of evidence. Although the use of PNOR Model which is based on OSHA CEHD monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides an upper-bound estimate of exposures.

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
Waste handling, treatment, and disposal	EPA considered the assessment approach, the quality of the data, and uncertainties in assessment results to determine a weight of scientific evidence conclusion for the full-shift TWA inhalation exposure estimates for the waste handling, treatment, and disposal OES. EPA utilized the PNOR Model (U.S. EPA, 2021b) to estimate worker inhalation exposure to solid particulate. The respirable particulate concentrations used by the generic model are based on OSHA CEHD data (OSHA, 2019). EPA used a subset of the respirable particulate data from the generic model identified with the Administrative and Support and Waste Management and Remediation Services NAICS code (NAICS code 56) to assess this OES, which EPA expects to be the most representative subset of the particulate data for this OES. EPA estimated the highest expected concentration of DBP in plastic using plasticizer additive concentration information from the Generic Scenario for the Use of Additives in Plastic Compounding (U.S. EPA, 2021c). These strengths increase the weight of evidence. The primary limitation is the uncertainty in the representativeness of values toward the true distribution of potential inhalation exposures. Specifically, EPA lacks facility-specific particulate concentrations in air, and the representativeness of the data set used in the model towards sites that actually handle DBP is uncertain. Further, the model lacks metadata on worker activities. EPA set the number of exposure days for both central tendency and high-end exposure estimates at 250 days per year based on EPA default assumptions. Also, it was assumed that each worker is potentially exposed for 8 hours per workday; however, it is uncertain whether this captures actual worker schedules and exposures. These limitations decrease the weight of evidence. Although the use of PNOR Model, which is based on OSHA CEHD monitoring data increases the strength of the analysis, but few uncertainties discussed in the paragraph above reduces confidence of the analysis. Therefore, based on these strengths and limitations, EPA has concluded that the weight of scientific evidence for this assessment is moderate and provides an upper-bound estimate of exposures.
Dermal – liquids	EPA used dermal absorption data for seven percent oil-in-water DBP formulations to estimate occupational dermal exposures for liquid (Doan et al., 2010). The tests were performed on guinea pigs, which have more permeable skin than humans (OECD, 2004c), meaning the dermal absorption value is likely protective for human skin. However, it is acknowledged that variations in chemical concentration and co-formulant components affect the rate of dermal absorption. Additionally, it is unclear how representative the data from Doan et al. (2010) are for neat DBP. Since, EPA assumed absorptive flux of DBP measured from guinea pig experiments serves as an upper-bound of potential absorptive flux of chemical into and through the skin for dermal contact with all liquid products. EPA is confident that the dermal absorption data using guinea pigs provides an upper-bound of dermal absorption of DBP. For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. For average adult workers, the surface area of contact was assumed equal to the area of one hand (*i.e.*, 535 cm^2), or two hands (*i.e.*, 1,070 cm^2), for central tendency exposures, or high-end exposures, respectively (U.S. EPA, 2011). Other parameters such as frequency and duration of use, and surface area in contact, are well understood and

OES	Weight of Scientific Evidence Conclusion in Exposure Estimates
	representative. Despite moderate confidence in the estimated values themselves, EPA has robust confidence that the dermal liquid exposure estimates are upper-bound of potential exposure scenarios.
Dermal – solids	It is expected that dermal exposure to solid matrices would result in far less absorption, but there are no studies that report dermal absorption of DBP from a solid matrix. For cases of dermal absorption of DBP from a solid matrix, EPA assumed that DBP will first migrate from the solid matrix to a thin layer of moisture on the skin surface. Therefore, absorption of DBP from solid matrices is considered limited by aqueous solubility and is estimated using an aqueous absorption model (U.S. EPA, 2023b, 2004b). Nevertheless, it is assumed that absorption of the aqueous material serves as a reasonable upper-bound for contact with solid materials. Also, EPA acknowledges that variations in chemical concentration and co-formulant components affect the rate of dermal absorption. For OES with lower concentrations of DBP in the solid, it is possible that the estimated amount absorbed using the modeled flux value would exceed the amount of DBP available in the dermal load. In these cases, EPA capped the amount absorbed to the maximum amount of DBP in the solid (*i.e.*, the product of the dermal load and the weight fraction of DBP). For occupational dermal exposure assessment, EPA assumed a standard 8-hour workday and the chemical is contacted at least once per day. Because DBP has low volatility and relatively low absorption, it is possible that the chemical remains on the surface of the skin after dermal contact until the skin is washed. So, in absence of exposure duration data, EPA has assumed that absorption of DBP from occupational dermal contact with materials containing DBP may extend up to 8 hours per day (U.S. EPA, 1991). However, if a worker uses proper personal protective equipment (PPE) or washes their hands after contact with DBP or DBP-containing materials dermal exposure may be eliminated. Therefore, the assumption of an 8-hour exposure duration for DBP may lead to overestimation of dermal exposure. EPA also assumed an area of contact for average adult workers ranging from 535 cm^2 (central tendency) to 1,070 cm^2 (high-end) (U.S. EPA, 2011). The occupational dermal exposure assessment is limited in that it does not consider the uniqueness of each material potentially contacted. But, the dermal exposure estimates are expected to be representative of materials potentially encountered in occupational settings. Therefore, the dermal absorption estimates assume that dermal absorption of DBP from solid objects would be limited by the aqueous solubility of DBP. EPA has moderate confidence in the aspects of the exposure estimate for solid articles because of the high uncertainty in the assumption of partitioning from solid to liquid, and because subsequent dermal absorption is not well characterized. Additionally, there are uncertainties associated to the flux-limited approach which likely results in overestimations due to the assumption about excess DBP in contact with skin for the entire work duration. Other parameters such as frequency and duration of use, and surface area in contact have unknown uncertainties due to lack of information about use patterns. Despite moderate confidence in the estimated values themselves, EPA has robust confidence that the exposure estimates are upper-bound of potential exposure scenarios.

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APPENDICES

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

This report assesses DBP inhalation exposures to workers in occupational settings, presented as 8-hour time weighted average (TWA). The full-shift TWA exposures are then used to calculate acute doses (AD), intermediate average daily doses (IADD), and average daily doses (ADD) for chronic non-cancer risks. This report also assesses DBP dermal exposures to workers in occupational settings, presented as a dermal acute potential dose rate (APDR). The APDRs are then used to calculate the AD, IADD, and ADD. This appendix presents the equations and input parameter values used to estimate each exposure metric.

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

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

Equation_Apx A-1.

$$AD = \frac{C \times ED \times BR}{BW}$$

Where:

AD	=	Acute dose (mg/kg-day)
C	=	Contaminant concentration in air (TWA mg/m^3)
ED	=	Exposure duration (h/day)
BR	=	Breathing rate (m^3/h)
BW	=	Body weight (kg)

EPA used IADD to estimate intermediate risks from workplace exposures as follows:

Equation_Apx A-2.

$$IADD = \frac{C \times ED \times EF_{int} \times BR}{BW \times ID}$$

Where:

$IADD$	=	Intermediate average daily dose (mg/kg-day)
EF_{int}	=	Intermediate exposure frequency (days)
ID	=	Intermediate duration (days)

EPA used ADD to estimate chronic non-cancer risks from workplace exposures. EPA estimated ADD as follows:

Equation_Apx A-3.

$$ADD = \frac{C \times ED \times EF \times WY \times BR}{BW \times 365 \frac{days}{yr} \times WY}$$

Where:

ADD	=	Average daily dose for chronic non-cancer risk calculations

EF	=	Exposure frequency (day/year)
WY	=	Working years per lifetime (years)

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

EPA used AD to estimate acute risks from workplace dermal exposures using Equation_Apx A-4.

Equation_Apx A-4.

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

Where:

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

EPA used IADD to estimate intermediate risks from workplace dermal exposures using Equation_Apx A-5.

Equation_Apx A-5.

$$IADD = \frac{APDR \times EF_{int}}{BW \times ID}$$

Where:

$IADD$	=	Intermediate average daily dose (mg/kg-day)
EF_{int}	=	Intermediate exposure frequency (days)
ID	=	Days for intermediate duration (days)

EPA used ADD to estimate chronic non-cancer risks from workplace dermal exposures using Equation_Apx A-6.

Equation_Apx A-6.

$$ADD = \frac{APDR \times EF \times WY}{BW \times 365 \frac{days}{yr} \times WY}$$

Where:

ADD	=	Average daily dose for chronic non-cancer risk calculations
EF	=	Exposure frequency (day/year)
WY	=	Working years per lifetime (year)

A.3 Calculating Aggregate Exposure

EPA combined the expected dermal and inhalation exposures for each OES and worker type into a single aggregate exposure to reflect the potential total dose from both exposure routes.

Equation_Apx A-7.

$$AD_{aggregate} = AD_{dermal} + AD_{inhalation}$$

Where:

AD_{Dermal}	=	Dermal exposure acute retained dose (mg/kg-day)
$AD_{Inhalation}$	=	Inhalation exposure acute retained dose (mg/kg-day)
$AD_{Aggregate}$	=	Aggregated acute retained does (mg/kg-day).

IADD and ADD also follow the same approach for defining aggregate exposures.

A.4 Acute, Intermediate, and Chronic (Non-Cancer) Equation Inputs

EPA used the input parameter values in Table_Apx A-1 to calculate acute, intermediate, and chronic inhalation exposure risks. Where EPA calculated exposures using probabilistic modeling, EPA integrated the calculations into a Monte Carlo simulation. The EF and EF_{int} used for each OES can differ, and the appropriate sections of this report describe these values and their selection. This section describes the values that EPA used in the equations in Appendices A.1 and A.2 and summarized in Table_Apx A-1.

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

Parameter Name	Symbol	Value	Unit
Exposure Duration	ED	8	h/day
Breathing Rate	BR	1.25	m^3/h
Exposure Frequency	EF	208–250[a]	days/year
Exposure Frequency, Intermediate	EF_{int}	22	days
Days for Duration, Intermediate	ID	30	days
Working Years	WY	31 (50th percentile) 40 (95th percentile)	years
Body Weight	BW	80 (average adult worker) 72.4 (female of reproductive age)	kg
[a] Depending on OES			

A.4.1 Exposure Duration (ED)

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

A.4.2 Breathing Rate (BR)

EPA used a breathing rate, based on average worker breathing rates. The breathing rate accounts for the amount of air a worker breathes during the exposure period. The typical worker breathes about 10 m^3 of air in 8 hours or 1.25 m^3/h (U.S. EPA, 1991).

A.4.3 Exposure Frequency (EF)

EPA generally used a maximum exposure frequency of 250 days per year based on the assumptions of daily exposure during each working day, 5 workdays per week, and 2 weeks of vacation per year. However, for some OES where a range of exposure frequencies were possible, EPA used probabilistic modeling to estimate exposures and the associated exposure frequencies, resulting in exposure frequencies below 250 days per year. The relevant sections of this report describe EPA's estimation of exposure frequency and the associated distributions for each OES.

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

Equation_Apx A-8.

$$EF = AWD \times f$$

Where:

EF	=	Exposure frequency, the number of days per year a worker is exposed to the chemical (day/year)
AWD	=	Annual working days, the number of working days per year for an individual worker (day/year)
f	=	Fractional number of annual working days during which a worker is exposed to the chemical (unitless)

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

EPA identified approximately 140 NAICS codes applicable to the multiple conditions of use for the first 10 chemicals that underwent risk evaluation. For each NAICS code of interest, EPA looked up the average hours worked per employee per year at the most granular NAICS level available (*i.e.*, 4-, 5-, or 6-digit). EPA converted the working hours per employee to working days per year per employee assuming employees work an average of 8 hours per day. The average number of working days per year, or AWD, ranges from 169 to 282 days per year, with a 50th percentile value of 250 days per year. EPA repeated this analysis for all NAICS codes at the 4-digit level. The average AWD for all 4-digit NAICS codes ranges from 111 to 282 days per year, with a 50th percentile value of 228 days per year. Two hundred fifty days per year is approximately the 75th percentile of the distribution AWD for the 4-digit NAICS codes. In the absence of industry- and DBP-specific data, EPA assumed the parameter, f, is equal to 1 for all OESs.

A.4.4 Intermediate Exposure Frequency (EF_{int})

For DBP, the ID was set at 30 days. EPA estimated the maximum number of working days within the ID, using the following equation and assuming 5 working days/week:

Equation_Apx A-9.

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

A.4.5 Intermediate Duration (ID)

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

A.4.6 Working Years (WY)

EPA developed a triangular distribution for number of lifetime working years using the following parameters:

- Minimum value: BLS CPS tenure data with current employer as a low-end estimate of the number of lifetime working years: 10.4 years;
- Mode value: The 50th percentile of the tenure data with all employers from SIPP as a mode value for the number of lifetime working years: 36 years; and

- Maximum value: The maximum of the average tenure data with all employers from SIPP as a high-end estimate on the number of lifetime working years: 44 years.

This triangular distribution has a 50th percentile value of 31 years and a 95th percentile value of 40 years. EPA uses these values to represent the central tendency and high-end number of working years in the ADC calculations.

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

The U.S. Census Bureau (2019) Survey of Income and Program Participation (SIPP) provides information on *lifetime tenure with all employers*. SIPP is a household survey that collects data on income, labor force participation, social program participation and eligibility, and general demographic characteristics through a continuous series of national panel surveys of between 14,000 and 52,000 households (U.S. BLS, 2023). EPA analyzed the 2008 SIPP Panel Wave 1, a panel that began in 2008 and covers the interview months of September 2008 through December 2008 (U.S. Census Bureau, 2019). For this panel, lifetime tenure data are available by Census Industry Codes, which can be cross walked with NAICS codes.

SIPP data include fields that describe, for each surveyed worker, the industry in which they work (TJBIND1); their age (TAGE); and years of work experience *with all employers* over the surveyed individual's lifetime.[4] Census household surveys use different industry codes than the NAICS codes, so EPA converted these industry codes to NAICS using a published crosswalk (U.S. Census Bureau, 2012). EPA calculated the average tenure for the following age groups: (1) workers aged 50 (years) and older; (2) workers aged 60 (years) and older; and (3) workers of all ages employed at time of survey. The Agency used tenure data for age group "50 and older" to determine the high-end lifetime working years, because the sample size in this age group is often substantially higher than the sample size for age group "60 and older." For some industries, the number of workers surveyed, or the *sample size*, was too small to provide a reliable representation of the worker tenure in that industry. Therefore, EPA excluded data where the sample size was less than 5 from the analysis.

Table_Apx A-2 summarizes the average tenure for workers aged 50 and older from SIPP data. Although the tenure may differ for any given industry sector, there is no significant variability between the 50th and 95th percentile values of average tenure across manufacturing and non-manufacturing sectors.

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

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

Industry Sectors	Working Years			
	Average	50th Percentile	95th Percentile	Maximum
Manufacturing sectors (NAICS 31–33)	35.7	36	39	40
Non-manufacturing sectors (NAICS 42–81)	36.1	36	39	44
Source: (U.S. BLS, 2023) Note: Industries where sample size was <5 were excluded from this analysis.				

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

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

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

A.4.7 Body Weight (BW)

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

Appendix B SAMPLE CALCULATIONS FOR CALCULATING ACUTE, INTERMEDIATE, AND CHRONIC (NON-CANCER) OCCUPATIONAL EXPOSURES

Sample calculations for high-end and central tendency acute, intermediate, and chronic (non-cancer) doses for one condition of use, PVC plastics compounding, are demonstrated below for an average adult worker. The explanation of the equations and parameters used is provided in Appendix A.

B.1 Inhalation Exposures

B.1.1 Example High-End AD, IADD, and ADD Calculations

Calculating AD_{HE}:

$$AD_{HE} = \frac{C_{HE} \times ED \times BR}{BW}$$

$$AD_{HE} = \frac{2.9\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr}}{80\ kg} = 0.36\ \frac{\frac{mg}{kg}}{day}$$

Calculating $IADD_{HE}$:

$$IADD = \frac{C_{HE} \times ED \times BR \times EF_{int}}{BW \times ID}$$

$$IADD_{HE} = \frac{2.9\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 22\,\frac{days}{year}}{80\ kg \times 30\,\frac{days}{year}} = 0.26\ \frac{\frac{mg}{kg}}{day}$$

Calculating ADD_{HE}:

$$ADD_{HE} = \frac{C_{HE} \times ED \times BR \times EF \times WY}{BW \times 365\ \frac{days}{year} \times WY}$$

$$ADD_{HE} = \frac{2.9\ \frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 250\,\frac{days}{year} \times 40\ years}{80\ kg \times 365\,\frac{days}{year} \times 40\ years} = 0.25\,\frac{\frac{mg}{kg}}{day}$$

B.1.2 Example Central Tendency AD, IADD, and ADD Calculations

Calculating AD_{CT}:

$$AD_{CT} = \frac{C_{CT} \times ED \times BR}{BW}$$

$$AD_{CT} = \frac{0.34\,\frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr}}{80\ kg} = 4.3\ \times 10^{-2}\ \frac{\frac{mg}{kg}}{day}$$

Calculating $IADD_{CT}$:

$$IADD_{CT} = \frac{C_{CT} \times ED \times BR \times EF_{int}}{BW \times ID}$$

$$IADD_{CT} = \frac{0.34\,\frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 22\,\frac{days}{year}}{80\ kg \times 30\,\frac{days}{year}} = 3.1 \times 10^{-2}\ \frac{\frac{mg}{kg}}{day}$$

Calculating ADD_{CT}:

$$ADD_{CT} = \frac{C_{CT} \times ED \times BR \times EF \times WY}{BW \times 365\,\frac{days}{year} \times WY}$$

$$ADD_{CT} = \frac{0.34\,\frac{mg}{m^3} \times 8\,\frac{hr}{day} \times 1.25\,\frac{m^3}{hr} \times 250\,\frac{days}{year} \times 31\ years}{80\ kg \times 365\,\frac{days}{year} \times 31\ years} = 2.9 \times 10^{-2}\,\frac{\frac{mg}{kg}}{day}$$

B.2 Dermal Exposures

B.2.1 Example High-End AD, IADD, and ADD Calculations

Calculating AD_{HE}:

$$AD_{HE} = \frac{APDR}{BW}$$

$$AD_{HE} = \frac{0.36\,\frac{mg}{day}}{80\ kg} = 4.5 \times 10^{-3}\,\frac{mg}{kg\text{-}day}$$

Calculate $IADD_{HE}$:

$$IADD_{HE} = \frac{APDR \times EF_{int}}{BW \times ID}$$

$$IADD_{HE} = \frac{0.36\,\frac{mg}{day} \times 22\,\frac{day}{yr}}{80\ kg \times 30\,\frac{day}{yr}} = 3.3 \times 10^{-3}\,\frac{mg}{kg\text{-}day}$$

Calculate ADD_{HE} (non-cancer):

$$ADD_{HE} = \frac{APDR \times EF \times WY}{BW \times 365\,\frac{day}{yr} \times WY}$$

$$ADD_{HE} = \frac{0.36\ \frac{mg}{day} \times 250\frac{day}{yr} \times 40\ years}{80\ kg \times 365\frac{day}{yr} \times 40\ years} = 3.1 \times 10^{-3}\frac{mg}{kg\text{-}day}$$

B.2.2 Example Central Tendency AD, IADD, and ADD Calculations

Calculating AD_{CT}:

$$AD_{CT} = \frac{APDR}{BW}$$

$$AD_{CT} = \frac{0.18\frac{mg}{day}}{80\ kg} = 2.3 \times 10^{-3}\frac{mg}{kg\text{-}day}$$

Calculating $IADD_{CT}$:

$$IADD_{CT} = \frac{APDR \times EF_{int}}{BW \times ID}$$

$$IADD_{CT} = \frac{0.18\frac{mg}{day} \times 22\frac{days}{yr}}{80\ kg \times 30\frac{days}{yr}} = 1.7 \times 10^{-3}\frac{mg}{kg\text{-}day}$$

Calculate ADD_{CT} (non-cancer):

$$ADD_{CT} = \frac{APDR \times EF \times WY}{BW \times AT}$$

$$ADD_{CT} = \frac{0.18\frac{mg}{day} \times 223\frac{days}{yr} \times 31\ years}{80\ kg \times 365\frac{day}{yr} \times 31\ years} = 1.4 \times 10^{-3}\frac{mg}{kg\text{-}day}$$

Appendix C DERMAL EXPOSURE ASSESSMENT METHOD

C.1 Dermal Dose Equation

As described in Section 2.4.3, occupational dermal exposures to DBP are characterized using a flux-based approach to dermal exposure estimation. EPA capped the dermal dose based on typical dermal loading values (Q). Therefore, EPA used the lesser of Equation_Apx C-1 and Equation_Apx C-2 to estimate the acute potential dose rate (APDR) from occupational dermal exposures. The APDR (units of mg/day) characterizes the quantity of chemical that is potentially absorbed by a worker on a given workday.

Equation_Apx C-1.

$$APDR = \frac{J \times S \times t_{abs}}{PF}$$

Where:

J	=	Average absorptive flux through and into skin (mg/cm^2/h);
S	=	Surface area of skin in contact with the chemical formulation (cm^2);
t_{abs}	=	Duration of absorption (h/day)
PF	=	Glove protection factor (unitless, PF ≥ 1)

Equation_Apx C-2.

$$APDR = \frac{Q \times F_w \times S}{PF}$$

Where:

Q	=	Dermal loading of liquid or solid formulation (mg/cm^2);
F_w	=	Weight fraction of DBP in the liquid or solid formulation (unitless);

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

C.2 Parameters of the Dermal Dose Equation

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

Table_Apx C-1. Summary of Dermal Dose Equation Values

Input Parameter	Symbol	Value	Unit	Rationale
Absorptive Flux	J	Dermal Contact with Liquids: 2.35E−02 Dermal Contact with Solids:3.17E−04	$mg/cm^2/h$	See Appendix C.2.1
Surface Area	S	Workers: 535 (central tendency) 1,070 (high-end) Females of reproductive age: 445 (central tendency) 890 (high-end)	cm^2	See Appendix C.2.2
Absorption Time	t_{abs}	8	hr	See Appendix C.2.3
Dermal Loading	Q	Liquid Contact: 1.4 (central tendency) 2.1 (high-end) Liquid Immersion: 3.8 (central tendency) 10.3 (high-end) Solids Contact [a]: 900 (central tendency) 3,100 (high-end) Solid contact with container surfaces/solders/pastes: 450 (central tendency) 1,100 (high-end)	mg/cm^2 (liquids) mg/day (solids)	See Appendix C.2.4
DBP Weight Fraction	F_w	OES-specific	Unitless	See Appendix C.2.5
Glove Protection Factor	PF	1; 5; 10; or 20	Unitless	See Appendix C.2.6

[a] Solid skin loading values are presented as a product of Q and S based on available data.

C.2.1 Absorptive Flux

Dermal data were sufficient to characterize occupational dermal exposures to liquids or formulations containing DBP; however, dermal data were not sufficient to estimate dermal exposures to solids or articles containing DBP. Therefore, modeling efforts were used to estimate dermal exposures to solids or articles containing DBP. Dermal exposures to vapors are not expected to be significant due to the extremely low volatility of DBP, and therefore, are not included in the dermal exposure assessment of DBP.

C.2.1.1 Dermal Contact with Liquids or Formulations Containing DBP

As described in Section 2.4.3.2, EPA uses the steady-state flux of neat DBP over a 24-hour period from a 7-percent aqueous emulsion of 2.35×10^{-2} $mg/cm^2/h$ estimated from Doan et al. (2010). EPA assumes the same average absorptive flux would be representative of dermal contact with liquids or formulations containing DBP that may occur in occupational settings over an 8-hour work shift.

C.2.1.1 Dermal Contact with Solids or Articles Containing DBP

As described in Section 2.4.3.3, the average absorptive flux of DBP from solid matrices is expected to vary between 0.32 and 0.89 $\mu g/cm^2/h$ for durations between 1-hour and 8-hours based on aqueous absorption modeling from U.S. EPA (2004b). Using Equation 2- from Section 2.4.3.3, the average absorptive flux of DBP over an 8-hour exposure period is calculated as 0.32 $\mu g/cm^2/h$. Because it is assumed that DBP must first migrate from the solid matrix to a thin film of moisture on the surface of the skin, and that solubility of DBP by the moisture layer limits absorption, the 8-hour time weighted average aqueous flux value of 0.32 μg/cm^2/h was chosen as a representative value for dermal exposures to solids or articles containing DBP.

C.2.2 Surface Area

Regarding surface area of occupational dermal exposure, EPA assumed a high-end value of 1,070 cm^2 for male workers and 890 cm^2 for female workers. These high-end occupational dermal exposure surface area values are based on the mean two-hand surface area for adults of age 21 years or older from Chapter 7 of EPA's *Exposure Factors Handbook* (U.S. EPA, 2011). For central tendency estimates, EPA assumed the exposure surface area was equivalent to only a single hand (or one side of two hands) and used half the mean values for two-hand surface areas (*i.e.*, 535 cm^2 for male workers and 445 cm^2 for female workers).

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

C.2.3 Absorption Time

Though a splash or contact-related transfer of material onto the skin may occur instantaneously, the material may remain on the skin surface until the skin is washed. Because DBP does not rapidly absorb or evaporate, and the worker may contact the material multiple times throughout the workday, EPA assumes that absorption of DBP in occupational settings may occur throughout the entirety of an 8-hour work shift (U.S. EPA, 1991).

C.2.4 Dermal Loading

C.2.4.1 Liquid Dermal Loading

For contact with liquids in occupational settings, EPA assumed a range of dermal loading of 0.7 to 2.1 mg/cm^2 (U.S. EPA, 1992b) for tasks such as product sampling, loading/unloading, and cleaning as shown in the ChemSTEER Manual (U.S. EPA, 2015). More specifically, EPA has utilized the raw data of the (U.S. EPA, 1992b) study to determine a central tendency (50th percentile) dermal loading value of 1.4 mg/cm^2 and a high-end (95th percentile) dermal loading value of 2.1 mg/cm^2 for dermal exposure to liquids. For scenarios where liquid immersion occurs, EPA assumed a range of dermal loading of 1.3 to 10.3 mg/cm^2 (U.S. EPA, 1992b) for tasks such as spray coating as shown in the ChemSTEER Manual (U.S. EPA, 2015). More specifically, EPA has utilized the raw data of the (U.S. EPA, 1992b) study to determine a central tendency (50th percentile) value of 3.8 mg/cm^2 and a high-end (95th percentile) value of 10.3 mg/cm^2 for scenarios aligned with dermal immersion in liquids.

C.2.4.2 Solid Dermal Loading

For contact with solids or powders in occupational settings, EPA generally assumed a range of dermal loading of 900 to 3,100 mg/day (50–95th percentile from Lansink *et al.* (1996)) as shown in the ChemSTEER Manual (U.S. EPA, 2015). For contact with materials such as solder/pastes in occupational settings, EPA assumed a range of dermal loading of 450 to 1,100 mg/day (50–95th percentile from Lansink et al. (1996)) as shown in the ChemSTEER Manual (U.S. EPA, 2015).

The average absorptive flux of DBP for an 8-hour absorption period, as determined through modeling efforts (U.S. EPA, 2023b, 2004b), would result in maximum absorption of 2.5×10^{-3} mg/cm^2 over an 8-hour period (2.71 mg/day for high-end worker exposures and 1.36 mg/day for central tendency worker exposures). Therefore, the high-end dermal exposure estimate for neat solid DBP is reasonable with respect to the amount of material that may be available for absorption in an occupational setting. However, for OES where more dilute formulations of DBP may be used, it is possible that the estimated amount absorbed using the modeled flux value would exceed the amount of DBP available in the dermal load. In these cases, EPA capped the amount absorbed to the maximum amount of DBP in the formulation (*i.e.*, the product of the dermal load and the weight fraction of DBP).

C.2.5 DBP Weight Fraction

Due to uncertainties around how different formulations of DBP may impact the overall dermal absorption, EPA used the maximum weight fraction of DBP in each OES to provide the most protective dermal exposure assessment. The details of the range of expected weight fractions of DBP in each OES are described for each OES in Section 3. Table Apx C-2 presents the weight fraction of DBP used for the dermal exposure of each OES.

Table Apx C-2. Summary of DBP Weight Fractions for Dermal Exposure Estimates

OES	Physical Form	Weight Fraction
Manufacturing	Liquid	1
Import and repackaging	Liquid	1
Incorporation into formulation, mixture, or reaction product	Liquid	1
PVC plastics compounding	Liquid	1
	Solid	0.45
PVC plastic converting	Solid	0.45
Non-PVC material manufacturing	Liquid	1
	Solid	0.2
Application of adhesives and sealants	Liquid	0.75
Application of paints and coatings	Liquid	0.1
Use of laboratory chemicals	Liquid	0.1
	Solid	0.2
Industrial process solvent use	Liquid	1
Use of lubricants and functional fluids	Liquid	0.075
Use of penetrants and inspection fluids	Liquid	0.2
Recycling	Solid	0.45
Fabrication or use of final product or articles	Solid	0.45
Waste handling, treatment, and disposal	Solid	0.45

C.2.6 Glove Protection Factors

Gloves may mitigate dermal exposures, if used correctly and consistently. However, data about the frequency of effective glove use—that is, the proper use of effective gloves—is very limited in industrial settings. Initial literature review suggests that there is unlikely to be sufficient data to justify a specific probability distribution for effective glove use for a chemical or industry. Instead, the impact of effective glove use should be explored by considering different percentages of effectiveness (*e.g.*, 25 vs. 50% effectiveness).

Gloves only offer barrier protection until the chemical breaks through the glove material. Using a conceptual model, Cherrie et al. (2004) proposed a glove workplace protection factor: the ratio of estimated uptake through the hands without gloves to the estimated uptake though the hands while wearing gloves (this protection factor is driven by flux and varies with time). The ECETOC TRA Model represents the protection factor of gloves as a fixed, PF equal to 5, 10, or 20 (Marquart et al., 2017). Where, similar to the APR for respiratory protection, the inverse of the protection factor is the fraction of the chemical that penetrates the glove.

Given the limited state of knowledge about the protection afforded by gloves in the workplace, it is reasonable to utilize the PF values of the ECETOC TRA Model (Marquart et al., 2017), rather than attempt to derive new values.

Table_Apx C-3 presents the PF values from ECETOC TRA Model (v3). In the exposure data used to evaluate the ECETOC TRA Model, (Marquart et al., 2017) reported that the observed glove protection factor was 34, compared to PF values of 5 or 10 used in the model.

Table_Apx C-3. Exposure Control Efficiencies and Protection Factors for Different Dermal Protection Strategies from ECETOC TRA V3

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

Appendix D MODEL APPROACHES AND PARAMETERS

This appendix presents the modeling approach and model equations used in estimating environmental releases and occupational exposures for each of the applicable OESs. The models were developed through review of the literature and consideration of existing EPA/OPPT models, ESDs, and/or GSs. An individual model input parameter could either have a discrete value or a distribution of values. EPA assigned statistical distributions based on reasonably available literature data. A Monte Carlo simulation (a type of stochastic simulation) was conducted to capture variability in the model input parameters. The simulation was conducted using the Latin Hypercube sampling method in @Risk Industrial Edition, Version 8.0.0 (Palisade, 2022). The Latin Hypercube sampling method generates a sample of possible values from a multi-dimensional distribution and is considered a stratified method, meaning the generated samples are representative of the probability density function (variability) defined in the model. EPA performed the model at 100,000 iterations to capture a broad range of possible input values, including values with low probability of occurrence.

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

D.1 EPA/OPPT Standard Models

This appendix discusses the standard models used by EPA to estimate environmental releases of chemicals and occupational inhalation exposures. All the models presented in this appendix are models that were previously developed by EPA and are not the result of any new model development work for this risk evaluation. Therefore, this appendix does not provide the details of the derivation of the model equations which have been provided in other documents such as the ChemSTEER User Guide (U.S. EPA, 2015), *Chemical Engineering Branch Manual for the Preparation of Engineering Assessments, Volume 1* (U.S. EPA, 1991), Evaporation of Pure Liquids from Open Surfaces (Arnold and Engel, 2001), Evaluation of the Mass Balance Model Used by the References Environmental Protection Agency for Estimating Inhalation Exposure to New Chemical Substances (Fehrenbacher and Hummel, 1996), and Releases During Cleaning of Equipment (Associates, 1988). The models include loss fraction models as well as models for estimating chemical vapor generation rates used in subsequent model equations to estimate the volatile releases to air and occupational inhalation exposure concentrations. The parameters in the equations of this appendix are specific to calculating environmental releases and occupational inhalation exposures to DBP.

The EPA/OPPT Penetration Model estimates releases to air from evaporation of a chemical from an open, exposed liquid surface (U.S. EPA, 2015). This model is appropriate for determining volatile releases from activities that are performed indoors or when air velocities are expected to be less than or equal to 100 feet per minute. The EPA/OPPT Penetration Model calculates the average vapor generation rate of the chemical from the exposed liquid surface using the following equation:

Equation_Apx D-1.

$$G_{activity} = \frac{(8.24 \times 10^{-8}) * (MW_{DBP}^{0.835}) * F_{correction\_factor} * VP * \sqrt{Rate_{air\_speed}} * (0.25\pi D_{opening}^{2}) \sqrt[4]{\frac{1}{29} + \frac{1}{MW_{DBP}}}}{T^{0.05} * \sqrt{D_{opening}} * \sqrt{P}}$$

Where:

$G_{activity}$	=	Vapor generation rate for activity (g/s)
MW_{DBP}	=	DBP molecular weight (g/mol)

$F_{correction\_factor}$	=	Vapor pressure correction factor (unitless)
VP	=	DBP vapor pressure (torr)
$Rate_{air\_speed}$	=	Air speed (cm/s)
$D_{opening}$	=	Diameter of opening (cm)
T	=	Temperature (K)
P	=	Pressure (torr)

The EPA/OPPT Mass Transfer Coefficient Model estimates releases to air from the evaporation of a chemical from an open, exposed liquid surface (U.S. EPA, 2015). This model is appropriate for determining this type of volatile release from activities that are performed outdoors or when air velocities are expected to be greater than 100 feet per minute. The EPA/OPPT Mass Transfer Coefficient Model calculates the average vapor generation rate of the chemical from the exposed liquid surface using the following equation:

Equation_Apx D-2.

$$G_{activity} = \frac{(1.93 \times 10^{-7}) * \left(MW_{DBP}{}^{0.78}\right) * F_{correction\_factor} * VP * Rate_{air\_speed}^{0.78} * (0.25\pi D_{opening}^{2})^{3}\sqrt{\frac{1}{29} + \frac{1}{MW_{DBP}}}}{T^{0.4} D_{opening}^{0.11} (\sqrt{T} - 5.87)^{2/3}}$$

Where:

$G_{activity}$	=	Vapor generation rate for activity (g/s)
MW_{DBP}	=	DBP molecular weight (g/mol)
$F_{correction\_factor}$	=	Vapor pressure correction factor (unitless)
VP	=	DBP vapor pressure (torr)
$Rate_{air\_speed}$	=	Air speed (cm/s)
$D_{opening}$	=	Diameter of opening (cm)
T	=	Temperature (K)

The EPA's Office of Air Quality Planning and Standards (OAQPS) AP-42 Loading Model estimates releases to air from the displacement of air containing chemical vapor as a container/vessel is filled with a liquid (U.S. EPA, 2015). This model assumes that the rate of evaporation is negligible compared to the vapor loss from the displacement and is used as the default for estimating volatile air releases during both loading activities and unloading activities. This model is used for unloading activities because it is assumed while one vessel is being unloaded another is to be loaded. The EPA/OAQPS AP-42 Loading Model calculates the average vapor generation rate from loading or unloading using the following equation:

Equation_Apx D-3.

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

Where:

$G_{activity}$	=	Vapor generation rate for activity (g/s)
$F_{saturation\_factor}$	=	Saturation factor (unitless)
MW_{DBP}	=	DBP molecular weight (g/mol)
$V_{container}$	=	Volume of container (gal/container)
$F_{correction\_factor}$	=	Vapor pressure correction factor (unitless)
VP	=	DBP vapor pressure (torr)

$RATE_{fill}$	=	Fill rate of container (containers/h)
R	=	Universal gas constant (L*torr/mol-K)
T	=	Temperature (K)

For each of the vapor generation rate models, the vapor pressure correction factor ($F_{correction\_factor}$) can be estimated using Raoult's Law and the mole fraction of DBP in the liquid of interest. However, in most cases, EPA did not have data on the molecular weights of other components in the liquid formulations; therefore, the Agency approximated the mole fraction using the mass fraction of DBP in the liquid of interest. Using the mass fraction of DBP to estimate mole fraction does create uncertainty in the vapor generation rate model. If other components in the liquid of interest have similar molecular weights as DBP, then mass fraction is a reasonable approximation of mole fraction. However, if other components in the liquid of interest have much lower molecular weights than DBP, the mass fraction of DBP will be an overestimate of the mole fraction. If other components in the liquid of interest have much higher molecular weights than DBP, the mass fraction of DBP will underestimate the mole fraction.

If calculating an environmental release, the vapor generation rate calculated from one of the above models (Equation_Apx D-1, Equation_Apx D-2, and Equation_Apx D-3) is then used along with an operating time to calculate the release amount:

Equation_Apx D-4.

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

Where:

$Release\_Year_{activity}$	=	DBP released for activity per site-year (kg/site-year)
$Time_{activity}$	=	Operating time for activity (h/site-year)
$G_{activity}$	=	Vapor generation rate for activity (g/s)

In addition to the vapor generation rate models, EPA uses various loss fraction models to calculate environmental releases, including the following:

- EPA/OPPT Small Container Residual Model;
- EPA/OPPT Drum Residual Model;
- EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders;
- EPA/OPPT Multiple Process Vessel Residual Model;
- EPA/OPPT Single Process Vessel Residual Model;
- EPA/OPPT Solid Residuals in Transport Containers Model; and
- March 2023 Methodology for Estimating Environmental Releases from Sampling Waste.

The loss fraction models apply a given loss fraction to the overall throughput of DBP for the given process. More information for each model can be found in the ChemSTEER User Guide (U.S. EPA, 2015). The loss fraction value or distribution of values differs for each model; however, each model follows the same general equation based on the approaches described for each OES:

Equation_Apx D-5.

$$Release\_Year_{activity} = PV * F_{activity\_loss}$$

Where:

$Release\_Year_{activity}$ = DBP released for activity per site-year (kg/site-year)
PV = Production volume throughput of DBP (kg/site-year)
$F_{activity\_loss}$ = Loss fraction for activity (unitless)

The EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders estimates a loss fraction of dust that may be generated during the transferring/unloading of solid powders. This model can be used to estimate a loss fraction of dust both when the facility does not employ capture technology (*i.e.*, local exhaust ventilation, hoods) or dust control/removal technology (*i.e.*, cyclones, electrostatic precipitators, scrubbers, or filters), and when the facility does employ capture and/or control/removal technology. The model explains that when dust is uncaptured, the release media is fugitive air, water, incineration, or landfill. When dust is captured but uncontrolled, the release media is to stack air. When dust is captured and controlled, the release media is to incineration or landfill, depending on the control technology. The EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders calculates the amount of dust not captured, captured but not controlled, and both captured and controlled, using the following equations (U.S. EPA, 2021b):

Equation_Apx D-6.

$$\mathrm{Elocal}_{\mathrm{dust\_not\_captured}} = \mathrm{Elocal}_{\mathrm{dust\_generation}} * \left(1 - \mathrm{F}_{\mathrm{dust\_capture}}\right)$$

Where:

$Elocal_{dust\_not\_captured}$ = Daily amount emitted from transfers/unloading that is not captured (kg not captured/site-day)
$Elocal_{dust\_generation}$ = Daily release of dust from transfers/unloading (kg generated/site-day)
$F_{dust\_capture}$ = Capture technology efficiency (kg captured/kg generated)

Equation_Apx D-7.

$$Elocal_{dust\_cap\_uncontrol} = Elocal_{dust\_generation} * F_{dust\_capture} * \left(1 - F_{dust\_control}\right)$$

Where:

$Elocal_{dust\_cap\_uncontrol}$ = Daily amount emitted from capture technology from transfers/unloading (kg not controlled/site-day)
$Elocal_{dust\_generation}$ = Daily release of dust from transfers/unloading (kg generated/site-day)
$F_{dust\_capture}$ = Capture technology efficiency (kg captured/kg generated)
$F_{dust\_control}$ = Control technology removal efficiency (kg controlled/kg captured)

Equation_Apx D-8.

$$Elocal_{dust\_cap\_control} = Elocal_{dust\_generation} * F_{dust\_capture} * F_{dust\_control}$$

Where:

$Elocal_{dust\_cap\_control}$	=	Daily amount captured and removed by control technology from transfers/unloading (kg controlled/site-day)
$Elocal_{dust\_generation}$	=	Daily release of dust from transfers/unloading (kg generated/site-day)
$F_{dust\_capture}$	=	Capture technology efficiency (kg captured/kg generated)
$F_{dust\_control}$	=	Control technology removal efficiency (kg controlled/kg captured)

EPA uses the above equations in the DBP environmental release models, and EPA references the model equations by model name and/or equation number within Appendix D.

D.2 Manufacturing Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DBP during the Manufacturing OES. This approach utilizes CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation (a type of stochastic simulation).

Based on DBP's physical properties and a virtual tour of the manufacturing processes for other phthalates (DIDP and DINP) (ExxonMobil, 2022b), EPA identified the following potential release sources from manufacturing operations:

- Release source 1: Vented Losses to Air During Reaction/Separations/Other Process Operations
- Release source 2: Product Sampling Wastes
- Release source 3: Equipment Cleaning Wastes
- Release source 4: Open Surface Losses to Air During Equipment Cleaning
- Release source 5: Transfer Operation Losses to Air from Packaging Manufactured DBP into Transport Containers

Environmental releases for DBP during manufacturing are a function of DBP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: DBP concentration, production volume, air speed, diameter of openings, saturation factor, container size, and loss fractions. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts and exposure concentrations for this OES.

D.2.1 Model Equations

Table_Apx D-1 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the Manufacturing OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix D.2.2. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx D-1. Models and Variables Applied for Release Sources in the Manufacturing OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Vented Losses to Air During Reaction/Separations/Other Process Operations	See Equation_Apx D-9	Q_{DBP_day}; F_{DBP_SPERC}
Release source 2: Product Sampling Wastes	March 2023 Methodology for Estimating Environmental Releases from Sampling Waste (Appendix D.1)	Q_{DBP_day}; $LF_{sampling}$
Release source 3: Equipment Cleaning Wastes	EPA/OPPT Multiple Process Vessel Residual Model (Appendix D.1)	Q_{DBP_day}; LF_{equip_clean}
Release source 4: Open Surface Losses to Air During Equipment Cleaning	EPA/OPPT Penetration Model or EPA/OPPT Mass Transfer Coefficient Model, based on air speed (Appendix D.1)	Vapor Generation Rate: F_{DBP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 5: Transfer Operation Losses to Air from Packaging Manufactured DBP into Transport Containers	EPA/OAQPS AP-42 Loading Model (Appendix D.1)	Vapor Generation Rate: F_{DBP}; VP; f_{sat}; MW; R; T; $RATE_{fill\_drum}$ Operating Time: $N_{cont\_load\_year}$; $RATE_{fill\_drum}$; OD

Release source 1 daily release (Vented Losses to Air During Reaction/Separations/Other Process Operations) is calculated using the following equation:

Equation_Apx D-9.

$$Release\_perDay_{RP1} = Q_{DBP\_day} * F_{DBP\_SPERC}$$

Where:

$Release\_perDay_{RP1}$ = DBP released for release source 1 (kg/site-day)
Q_{DBP_day} = Facility throughput of DBP (kg/site-day)
F_{DBP_SPERC} = Loss fraction for unit operations (unitless)

D.2.2 Model Input Parameters

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

5118 **Table_Apx D-2. Summary of Parameter Values and Distributions Used in the Manufacturing Models**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Number of Sites with CBI	Ns	sites	4	–	–	–	–	See D.2.3
Facility Production Rate – Known Site	PV1	kg/site-year	23,520	–	–	–	Uniform	See D.2.4
Facility Production Rate – Sites with CBI	PV2	kg/site-year	2,382,450	49,689	2,382,450	–	Uniform	See D.2.4
Manufactured DBP Concentration (Known Site)	F_{DBP_1}	kg/kg	1.0	0.90	1.0	–	Uniform	See D.2.7
Manufactured DBP Concentration (Sites with CBI)	F_{DBP_2}	kg/kg	1.0	0.01	1.0	–	Uniform	See D.2.7
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	–	Lognormal	See D.2.8
Diameter of Equipment Opening	D_{equip_clean}	cm	92	–	–	–	–	See D.2.9
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See D.2.10
Drum Size	V_{drum}	gal	100	20	1000	100	Triangular	See D.2.11
Fraction of DBP Lost During Sampling – 1 (Q_{DBP_day} <50 kg/site-day)	$F_{sampling\_1}$	kg/kg	2.0E−02	2.0E−03	2.0E−02	2.0E−02	Triangular	See D.2.12
Fraction of DBP Lost During Sampling – 2 (Q_{DBP_day} 50–200 kg/site-day)	$F_{sampling\_2}$	kg/kg	5.0E−03	6.0E−04	5.0E−03	5.0E−03	Triangular	See D.2.12
Fraction of DBP Lost During Sampling – 3 (Q_{DBP_day} 200–5000 kg/site-day)	$F_{sampling\_3}$	kg/kg	4.0E−03	5.0E−04	4.0E−03	4.0E−03	Triangular	See D.2.12
Fraction of DBP Lost During Sampling – 4 (Q_{DBP_day} >5,000 kg/site-day)	$F_{sampling\_4}$	kg/kg	4.0E−04	8.0E−05	4.0E−04	4.0E−04	Triangular	See D.2.12
Operating Days	OD	days/year	300	–	–	–	–	See D.2.13
Vapor Pressure at 25 °C	VP	mmHg	2.0E−05	–	–	–	–	Physical property
Vapor Pressure at 375 °F	VP_{375}	mmHg	37	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	278	–	–	–	–	Physical property

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Density of DBP	RHO	kg/L	1.04	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82.05	–	–	–	–	Universal constant
Process Operation Emission Factor	F_{DBP_SPERC}	kg/kg	1.0E−05	–	–	–	–	See D.2.14
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1.0	–	–	–	–	Process parameter
Equipment Cleaning Loss Fraction	LF_{equip_clean}	kg/kg	2.0E−02	–	–	–	–	See D.2.15
Drum Fill Rate	$RATE_{fill\_drum}$	drums/h	20	–	–	–	–	See D.2.16

D.2.3 Number of Sites

EPA used 2020 CDR data (U.S. EPA, 2020a) to identify the number of sites that manufacture DBP. In CDR, two sites reported domestic manufacturing of DBP, Dystar LP located in Reidsville, North Carolina and one site, Polymer Additives Inc, that reported their PV as CBI. An additional three sites reported both their locations and site activities as CBI; EPA assumed that these sites may manufacture DBP. This resulted in a total of five potential DBP manufacturing sites. Table_Apx D-3 presents the names and locations of these sites.

Table_Apx D-3. Sites Reporting to CDR for Domestic Manufacture of DBP

Facility Name	Facility Location
Dystar LP	Reidsville, NC
Polymer Additives, Inc.	Bridgeport, NJ
3 additional CBI sites	CBI

D.2.4 Throughput Parameters

EPA ran the Monte Carlo model separately to estimate releases and exposures from the single site with a known production volume (Dystar LP) and to estimate releases and exposures from the other four sites that claimed their production volumes (PVs) as CBI. EPA used 2020 CDR data (U.S. EPA, 2020a) to identify annual facility PV for each site. Dystar LP reported 51,852 lb (23,520 kg) of DBP manufactured.

For the other four sites, EPA used a uniform distribution set within the national PV range for DBP. EPA calculated the bounds of the range by taking the total PV range in CDR and subtracting out the PVs that belonged to known sites (both manufacturing and import). Then, for each bound of the PV range for the remaining sites with CBI PVs, EPA divided the value by the remaining four sites. CDR estimates a total national DBP PV of 1,000,000 to 10,000,000 lb. Based on the known PVs from importers and manufacturers, the total PV associated with the four sites with CBI PVs is 109,546 to 5,252,403 lb/year. After converting from lb to kg, EPA set a uniform distribution for the PV for the four sites with CBI or withheld PVs with lower-bound of 49,689 kg/year, and an upper-bound of 2,382,450 kg/year.

The daily throughput of DBP is calculated using Equation_Apx D-10 by dividing the annual PV by the number of operating days.

Equation_Apx D-10.

$$Q_{DBP\_day} = \frac{PV}{OD * Nsites}$$

Where:

Q_{DBP_day}	=	Facility daily throughput of DBP (kg/site-day)
PV	=	Annual production volume (kg/site-year)
N_{sites}	=	Number of sites (1 known or 4 with CBI PVs depending on the run [see Appendix D.2.3])
OD	=	Operating days (see Appendix D.2.13) (days/year)

D.2.5 Number of Containers Per Year

The number of product containers filled with manufactured DBP by a site per year is calculated using the following equation:

Equation_Apx D-11.

$$N_{cont\_load\_year} = \frac{PV}{V_{drum}}$$

Where:

$N_{cont\_load\_year}$	=	Annual number of product containers (container/site-year)
PV	=	Annual production volume (see Appendix D.2.4) [kg/site-year])
V_{drum}	=	Product container volume (see Appendix D.2.11) [gal/container])

D.2.6 Operating Hours

EPA estimated operating hours or hours of duration for the applicable activities using data provided from the ChemSTEER User Guide (U.S. EPA, 2015) and/or through calculation from other parameters. Release points with operating hours provided from that User Guide include an estimate of 4 hours for equipment cleaning (release point 4).

The operating hours for loading of DBP into transport containers (release point 5) is calculated based on the number of product containers filled at the site and the fill rate using the following equation:

Equation_Apx D-12.

$$Time_{RP5} = \frac{N_{cont\_load\_year}}{RATE_{fill\_drum} * OD}$$

Where:

$Time_{RP5}$	=	Operating time for release point 5 (h/site-day)
$N_{cont\_load\_year}$	=	Annual number of product containers (see Appendix D.2.5) (containers/site-year)
$RATE_{fill\_drum}$	=	Fill rate of container (see Appendix D.2.16) [containers/h])
OD	=	Operating days (see Appendix D.2.13) (days/site-year)

D.2.7 Manufactured DBP Concentration

EPA used the manufactured DBP concentration range reported in CDR (U.S. EPA, 2020a) to make a uniform distribution of 90 to 100 percent DBP for the run using the known site PV. For the second run for the sites that reported CBI, EPA assumed a uniform distribution from 1 to 100 percent DBP based on reported information in the 2020 CDR.

D.2.8 Air Speed

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

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

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

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

D.2.9 Diameters of Opening

The ChemSTEER User Guide indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations (release point 4), the ChemSTEER User Guide indicates a single default value of 92 cm (U.S. EPA, 2015).

D.2.10 Saturation Factor

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

D.2.11 Container Size

Based on the PV range assessed, EPA assumed that DBP may be packaged in drums or totes. According to the ChemSTEER Manual Guide, drums are defined as containing between 20 and 100 gallons of liquid, with a default of 55 gallons while totes are defined as containing between 100 and 1,000 gallons, with a default of 550 gallons (U.S. EPA, 2015). Therefore, EPA modeled packaged container size using a triangular distribution with a lower-bound of 20 gallons, an upper-bound of 1,000 gallons, and a mode of 100 gallons (the maximum for drums and minimum for totes).

D.2.12 Sampling Loss Fraction

Sampling loss fractions were estimated using the March 2023 Methodology for Estimating Environmental Releases from Sampling Wastes (U.S. EPA, 2023c). In this methodology, EPA completed a search of over 300 Initial Review Engineering Report (IRERs) completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both Pre-Manufacture Notices (PMNs) and Low Volume Exemptions (LVEs). Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (≈75% of IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx D-4 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx D-4. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower-bound, and the 95th percentile value as the upper-bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Appendix D.2.4.

D.2.13 Operating Days

EPA was unable to identify specific information for operating days for the manufacturing of DBP. Therefore, EPA assumed a constant value of 300 days/year, which assumes the production sites operate six days per week and 50 weeks per year, with 2 weeks down for turnaround.

D.2.14 Process Operations Emission Factor

In order to estimate releases from reactions, separations, and other process operations, EPA used an emission factor from the European Solvents Industry Group (ESIG). According to the ESD on Plastic Additives, the processing temperature during manufacture of plasticizers is 375°F (OECD, 2009b). However, the rate of release is expected to be limited by the ambient temperature of the manufacturing facility. At room temperature, the vapor pressure of DBP is less than 1 Pa. The ESIG Specific Environmental Release Category for Industrial Substance Manufacturing (solvent-borne) states that a chemical with a vapor pressure of less than 1 Pa will have an emission factor of 0.00001 (ESIG, 2012). Therefore, EPA used this emission factor as a constant value for process operation releases.

D.2.15 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. That model, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

D.2.16 Container Fill Rates

The ChemSTEER User Guide (U.S. EPA, 2015) provides a typical fill rate of 20 containers per hour for containers with 20 to 1,000 gallons of material.

D.3 Application of Adhesives and Sealants Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DBP during the Application of adhesives and sealants OES. This approach utilizes the Emission Scenario Document on Use of Adhesives (OECD, 2015) combined with Monte Carlo simulation (a type of stochastic simulation). EPA assessed this OES with DBP arriving on site as an additive in liquid adhesive or sealant formulations; therefore, solid releases are not expected.

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

- Release source 1: Transfer Operation Losses from Unloading
- Release source 2: Container Cleaning Residues
- Release source 3: Open Surface Losses to Air During Container Cleaning
- Release source 4: Equipment Cleaning Releases
- Release source 5: Open Surface Losses to Air During Equipment Cleaning
- Release source 6: Process Releases During Adhesive Applications
- Release source 7: Open Surface Losses to Air During Curing/Drying
- Release source 8: Trimming Wastes

Environmental releases for DBP during use of adhesives and sealants are a function of DBP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: product throughput, DBP concentrations, air speed, container size, loss fractions, control technology efficiencies, and operating days. The Agency used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

D.3.1 Model Equations

Table_Apx D-5 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the Application of adhesives and sealants OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix D.1. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx D-5. Models and Variables Applied for Release Sources in the Application of Adhesives and Sealants OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses from Unloading	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 2: Container Cleaning Residues	EPA/OPPT Drum Residual Model or EPA/OPPT Bulk Transport Residual Model,	Q_{DBP_day}; $F_{drum\_residue}$; $F_{cont\_residue}$; V_{cont}; F_{DBP}; RHO

Release Source	Model(s) Applied	Variables Used
	based on container size (Appendix D.1)	
Release source 3: Open Surface Losses to Air During Container Cleaning	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 4: Equipment Cleaning Releases	EPA/OPPT Multiple Process Vessel Residual Model (Appendix D.1)	Q_{DBP_day}; $F_{equipment\_cleaning}$
Release source 5: Open Surface Losses to Air During Equipment Cleaning	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 6: Process Releases Losses During Adhesive Application	Unable to estimate due to lack of substrate surface area data	N/A
Release source 7: Open Surface Losses to Air During Curing/Drying	Unable to estimate due to a lack of the required data for DBP pertaining to curing times and conditions	N/A
Release source 8: Trimming Wastes	See Equation_Apx D-13	Q_{DBP_day}; $F_{trimming}$

Release source 8 daily release (Trimming Wastes) is calculated using the following equation:

Equation_Apx D-13.

$$Release\_perDay_{RP8} = Q_{DBP\_day} * F_{trimming}$$

Where:

$Release\_perDay_{RP8}$ = DBP released for release source 8 (kg/site-day)
Q_{DBP_day} = Facility throughput of DBP (see Appendix D.3.4) (kg/site-day)
$F_{trimming}$ = Fraction of DBP released as trimming waste (see Appendix D.3.11) (kg/kg)

D.3.2 Model Input Parameters

Table_Apx D-6 summarizes the model parameters and their values for the Application of Adhesives and Sealants Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after this table.

5331 **Table_Apx D-6. Summary of Parameter Values and Distributions Used in the Application of Adhesives and Sealants Model**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
DBP Production Volume for Adhesives/Sealants	PV	kg/year	2.1E06	9.9E04	2.1E06	–	Uniform	See D.3.3
Annual Facility Throughput of Adhesive/Sealant	$Q_{product\_year}$	kg/site-year	1.4E04	1,500	1.4E05	1.4E04	Triangular	See D.3.4
Adhesive/Sealant DBP Concentration	F_{DBP}	kg/kg	0.10	1.0E−03	0.75	0.10	Triangular	See D.3.7
Operating Days	OD	days/year	260	50	365	260	Triangular	See D.3.8
Container Volume	V_{cont}	gal	5.0	5.0	20	5.0	Triangular	See D.3.9
Container Residual Loss Fraction	$F_{cont\_residue}$	kg/kg	3.0E−03	3.0E−04	6.0E−03	3.0E−03	Triangular	See D.3.10
Fraction of DBP Released as Trimming Waste	$F_{trimming}$	kg/kg	4.0E−02	0	4.0E−02	4.0E−02	Triangular	See D.3.11
Vapor Pressure at 25 °C	VP	mmHg	2.0E−05	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	278	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82	–	–	–	–	Universal constant
Density of DBP	RHO	kg/L	1.0	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1.0	–	–	–	–	Process parameter
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/h	60	–	–	–	–	See D.3.12
Equipment Cleaning Loss Fraction	$F_{equipment\_cleaning}$	kg/kg	2.0E−02	–	–	–	–	See D.3.13

5332

D.3.3 Production Volume

EPA estimated the total DBP production volume for adhesive and sealant products using a uniform distribution with a lower-bound of 99,157 kg/year and an upper-bound of 2,140,323 kg/year. This range is based on DBP CDR data of site production volumes, national aggregate production volumes, and percentages of the production volumes going to various industrial sectors (U.S. EPA, 2020a).

There were two reporters that reported to CDR for use of DBP in adhesive/sealant or paint/coating products: G.J. Chemical Co, Inc. in Somerset, New Jersey, who reported a volume of 139,618 lb; and MAK Chemicals in Clifton, NJ, who reported a use volume of 105,884 lb of DBP. This equates to a total known use volume of 245,502 lb of DBP; however, there is still a large portion of the aggregate PV range for DBP that is not attached to a known use. A breakdown of the known production volume information is provided in Table_Apx D-7.

Table_Apx D-7. CDR Reported Site Information for Use in Calculation of Use of Adhesives, Sealants, Paints, and Coatings Production Volume

Site Name	Site Location	Reported Production Volume (lb/year)	Reported Use Industry/Products
Dystar LP	Reidsville, NC	51,852	Textiles, apparel, and leather manufacturing
Covalent Chemical	Raleigh, NC	88,184	Plastics material and resin manufacturing
MAK Chemicals	Clifton, NJ	105,884	Exterior car waxes, polishes, and coatings
GJ Chemical Co Inc	Newark, NJ	139,618	Hot-melt adhesives
Industrial Chemicals Inc	Vestavia Hills, AL	422,757	Plastics product manufacturing

According to CDR, the national aggregate PV range for manufacture and import of DBP in 2019 was between 1,000,000 to 10,000,000 lb. The sum of known production volumes for all uses is 808,295 lb (562,794 lb not associated with use of adhesives/sealants or paints and coatings). Due to uncertainty in the expected use of DBP and the number of identified products for these uses, EPA assumed that the remaining PV with unknown use is split between the use of adhesives and sealants and paint and coating products. Subtracting the PV with known use that are not associated with adhesives/sealants/paints/coatings from the aggregate national PV range equates to a range of

- Low-end: 1,000,000 lb to 562,793 lb = 437,207 lb (198,314 kg); and
- High-end: 10,000,000 lb to 562,793 lb = 9,437,207 lb (4,280,645 kg).

EPA assumed half of the calculated PV above is used in paints and coatings while the other half is used in adhesives and sealants. This results in a PV range of 99,157 to 2,140,323 kg/year across all sites for the application of adhesives and sealants.

D.3.4 Throughput Parameters

The annual throughput of adhesive and sealant product is modeled using a triangular distribution with a lower-bound of 1,500 kg/year, an upper-bound of 141,498 kg/year, and mode of 13,500 kg/year. This is based on the Emission Scenario Document on Use of Adhesives (OECD, 2015). The ESD provides default adhesive use rates based on end-use category. EPA compiled the end-use categories that were relevant to downstream uses for adhesives and sealants containing DBP, which included computer and electronic product manufacturing, motor and non-motor vehicles, vehicle parts and tire manufacturing, and general assembly. The lower- and upper-bound adhesive use rates for these categories was 1,500 to 141,498 kg/year. The mode is based on the ESD default for unknown end-use markets.

The annual throughput of DBP in adhesives/sealants is calculated using Equation_Apx D-14 by multiplying the annual throughput of all adhesives and sealants by the concentration of DBP in the adhesives/sealants.

Equation_Apx D-14.

$$Q_{DBP\_year} = Q_{product\_year} * F_{DBP}$$

Where:

Q_{DBP_year}	=	Facility annual throughput of DBP (kg/site-year)
$Q_{product\_year}$	=	Facility annual throughput of all adhesives/sealants (kg/site-year)
F_{DBP}	=	Concentration of DBP in adhesives/sealants (see Appendix D.3.7) (kg/kg)

The daily throughput of DBP is calculated using Equation_Apx D-15 by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Appendix D.3.8.

Equation_Apx D-15.

$$Q_{DBP\_day} = \frac{Q_{DBP\_year}}{OD}$$

Where:

Q_{DBP_day}	=	Facility daily throughput of DBP (kg/site-day)
Q_{DBP_year}	=	Facility annual throughput of DBP (kg/site-year)
OD	=	Operating days (see Appendix D.3.8) (days/year)

D.3.5 Number of Sites

Per 2020 U.S. Census Bureau data for the NAICS codes identified in the Emission Scenario Document on Use of Adhesives (OECD, 2015), there are 10,144 adhesive and sealant use sites (U.S. BLS, 2023). Therefore, this value is used as a bounding limit, not to be exceeded by the calculation. Number of sites is calculated using a per-site throughput and total production volume with the following equation:

Equation_Apx D-16.

$$N_s = \frac{PV}{Q_{DBP\_year}}$$

Where:

N_s	=	Number of sites (sites)
PV	=	DBP production volume for adhesives/sealants (kg/year)
Q_{DBP_year}	=	Facility annual throughput of DBP (kg/site-year)

D.3.6 Number of Containers Per Year

The number of DBP raw material containers received and unloaded by a site per year is calculated using the following equation:

Equation_Apx D-17.

$$N_{cont\_unload\_year} = \frac{Q_{product\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

$N_{cont\_unload\_year}$	=	Annual number of containers unloaded (container/site-year)
$Q_{product\_year}$	=	Facility annual throughput of all adhesives/sealants (see Appendix D.3.4) (kg/site-year)
RHO	=	DBP density (kg/L)
V_{cont}	=	Container volume (see Appendix D.3.9) (gal/container)

D.3.7 Adhesive/Sealant DBP Concentration

EPA determined DBP concentrations in final adhesive/sealant products using compiled SDS information (see Appendix E for EPA identified DBP-containing products for this OES). For final adhesive/sealant products, EPA developed the triangular distribution of DBP concentration using a lower-bound of 0.1 percent, an upper-bound of 75 percent, and a mode of 10 percent. The lower- and upper-bounds are based on the minimum and maximum concentrations compiled from SDS for multiple adhesives and sealant products containing DBP, excluding products with 0 or 100 percent DBP. The mode is based on the overall median of all high-end values of the provided product ranges.

D.3.8 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower-bound of 50 days/year, an upper-bound of 365 days/year, and a mode of 260 days/year. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 50 and 365 days/year. This is based on the Emission Scenario Document on Use of Adhesives (OECD, 2015). The ESD provides operating days for several end-use categories. The range of operating days for the end-use categories is 50 to 365 days/year. The mode of the distribution is based on the ESD's default of 260 days/year for unknown or general adhesive use cases.

D.3.9 Container Size

Based on identified products, EPA assumed that sites would receive adhesives and sealants in small containers (see Appendix E for a list of the DBP-containing products identified for this OES). According to the ChemSTEER User Guide, small containers are defined as containing between 5 and 20 gallons of material with a default size of 5 gallons (U.S. EPA, 2015). EPA modeled container size using a triangular distribution with a lower-bound of 5 gallons, an upper-bound of 20 gallons, and a mode of 5 gallons based on the defaults defined by the ChemSTEER User Guide.

D.3.10 Small Container Residue Loss Fraction

EPA used data from the PEI Associates Inc. study (Associates, 1988) for emptying drums by pouring along with central tendency and high-end values from the EPA/OPPT Small Container Residual Model. For unloading drums by pouring in the PEI Associates Inc. study (Associates, 1988), EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.03 to 0.79 percent and an average of 0.32 percent. The EPA/OPPT Small Container Residual Model from the ChemSTEER User Guide (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require least assumptions and are completely defined by range and mode of a parameter. The Agency assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the EPA/OPPT Small Container Residual Model in the ChemSTEER User Guide (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pouring.

D.3.11 Fraction of DBP Released as Trimming Waste

EPA modeled the fraction of DBP released as trimming waste using a triangular distribution with a lower-bound of 0, an upper-bound of 0.04, and a mode of 0.04. This is based on the Emission Scenario Document on Use of Adhesives (OECD, 2015). The ESD states that trimming losses should only be assessed if trimming losses are expected for the end use. Because not all adhesive and sealant end uses will result in trimming losses, EPA assigned a lower-bound of 0. The upper-bound and mode are based on the ESD's default trimming waste loss fraction of 0.04 kg chemical in trimmings/kg chemical applied.

D.3.12 Container Fill Rate

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

D.3.13 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. This model, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

D.4 Application of Paints and Coatings Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DBP during the Application of paints and coatings OES. This approach utilizes the Emission Scenario Document on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a), Emission Scenario Document on the Coating Industry (Paints, Lacquers, and Varnishes) (OECD, 2009c), and Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating (OECD, 2011b) combined with Monte Carlo simulation. DBP is used in standard liquid paints and coatings as well as components of two-part coating systems. All product SDSs identified indicate that DBP is present in liquid form (see Appendix E for EPA-identified, DBP-containing products for this OES). EPA modeled spray application as opposed to other application methods because it provides a more protective estimate of releases and exposures with the prevalence of each application method unknown for DBP-containing coatings. Based on the ESDs, EPA identified the following release sources from the application of paints and coatings:

- Release source 1: Transfer Operation Losses from Unloading
- Release source 2: Open Surface Losses to Air During Raw Material Sampling
- Release source 3: Container Cleaning Wastes
- Release source 4: Open Surface Losses to Air During Container Cleaning
- Release source 5: Process Releases During Application Operations
- Release source 6: Equipment Cleaning Wastes
- Release source 7: Open Surface Losses to Air During Equipment Cleaning

- Release source 8: Raw Material Sampling Wastes

Environmental releases for DBP during the application of paints and coatings are a function of DBP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume, paint and coating throughput, DBP concentrations, container size, loss fractions, control technology efficiencies, transfer efficiency, and operating days. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

D.4.1 Model Equations

Table_Apx D-8 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the Application of paints and coatings OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix D.1. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx D-8. Models and Variables Applied for Release Sources in the Application of Paints and Coatings OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses from Unloading	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 2: Open Surface Losses to Air During Raw Material Sampling	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 3: Container Cleaning Wastes	EPA/OAQPS AP-42 Small Container Residual Model (Appendix D.1)	Q_{DBP_day}; $F_{cont\_residue}$; $F_{drum\_residue}$; RHO; F_{DBP}; V_{cont}
Release source 4: Open Surface Losses to Air During Container Cleaning	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 5: Process Releases During Operations	See Equation_Apx D-18 through Equation_Apx D-22	Q_{DBP_day}; $F_{transfer\_eff}$; $F_{capture\_eff}$; $F_{solidrem\_eff}$
Release source 6: Equipment Cleaning Wastes	EPA/OPPT Multiple Process Vessel Residual Model (Appendix D.1)	Q_{DBP_day}; LF_{equip_clean}
Release source 7: Open Surface Losses to Air During Equipment Cleaning	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 8: Raw Material Sampling Wastes	March 2023 Methodology for Estimating Environmental	Q_{DBP_day}; $LF_{sampling}$

Release Source	Model(s) Applied	Variables Used
	Releases from Sampling Waste (Appendix D.1)	

Release source 5 (Process Releases During Operations) is partitioned out by release media depending upon the paint and coating overspray control technology employed. EPA modeled two scenarios: one scenario in the absence of control technology with a total release from release source 5 to unknown media (*i.e.*, a release to fugitive air, water, incineration, or landfill); and one scenario with control technology and releases partitioned to landfill, stack air, or water for release source 5 based on capture and removal efficiencies. In order to calculate the total release from release source 5, the following equation was used:

Equation_Apx D-18.

$$Release\_perDay_{RP5\_total} = Q_{DBP\_day} * \left(1 - F_{transfer\_eff}\right)$$

Where:

$Release\_perDay_{RP5\_total}$	=	DBP released for release source 5 to all release media (kg/site-day)
Q_{DBP_day}	=	Facility throughput of DBP (see Appendix) (kg/site-day)
$F_{transfer\_eff}$	=	Paint/coating transfer efficiency fraction (see Appendix D.4.12) (unitless)

Transfer efficiency is determined according to Appendix D.4.12. For the scenario in which control technologies are accounted for, the percent of the total release that is released to water is calculated using the following equation:

Equation_Apx D-19.

$$\%_{water} = F_{capture\_eff} * \left(1 - F_{solidrem\_eff}\right)$$

Where:

$\%_{water}$	=	Percent of release 5 that is released to water (unitless)
$F_{capture\_eff}$	=	Booth capture efficiency for spray-applied paints/coatings (see Appendix D.4.15) (kg/kg)
$F_{solidrem\_eff}$	=	Fraction of solid removed in the spray mist of sprayed paints/ coatings (see Appendix D.4.16) (kg/kg)

Booth capture efficiency is determined according to Appendix D.4.15, and solid removal efficiency is determined according to Appendix D.4.16. The percent of the total release that is released to stack air is calculated using the following equation:

Equation_Apx D-20.

$$\%_{air} = \left(1 - F_{capture\_eff}\right)$$

Where:

$\%_{air}$	=	Percent of release 5 that is released to stack air (unitless)
$F_{capture\_eff}$	=	Booth capture efficiency for spray-applied paints/ coatings (see Appendix D.4.15) (kg/kg)

The percent of the total release that is released to landfill is calculated using the following equation:

Equation_Apx D-21.

$$\%_{land} = F_{capture\_eff} * F_{solidrem\_eff}$$

Where:

$\%_{land}$	=	Percent of release 5 that is released to landfill (unitless)
$F_{capture\_eff}$	=	Booth capture efficiency for spray-applied paints/ coatings (see Appendix D.4.15) (kg/kg)
$F_{solidrem\_eff}$	=	Fraction of solid removed in the spray mist of sprayed paints/ coatings (see Appendix D.4.16) (kg/kg)

If control technologies are used, the release amounts to each media are calculated using the following equation:

Equation_Apx D-22.

$$Release\_perDay_{RP5\_media} = Release\_perDay_{RP5\_total} * \%_{media}$$

Where:

$Release\_perDay_{RP5\_media}$	=	Amount of release 5 that is released to water, air, or landfill (kg/site-day)
$Release\_perDay_{RP5\_total}$	=	DBP released for release source 5 to all release media (kg/site-day)
$\%_{media}$	=	Percent of release 5 that is released to water, air, or landfill (unitless)

D.4.2 Model Input Parameters

Table_Apx D-9 summarizes the model parameters and their values for the Application of Paints and Coatings Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after this table.

5589 **Table_Apx D-9. Summary of Parameter Values and Distributions Used in the Application of Paints and Coatings Model**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Production Volume of DBP	PV	kg/year	2.1E06	9.9E04	2.1E06	–	–	See D.4.3
Annual Facility Throughput of Paint/Coating	Q_{coat_year}	kg/site-year	5,704	946	4.5E05	5,704	Triangular	See D.4.5
Paint/Coating DBP Concentration	F_{DBP}	kg/kg	2.5E−02	1.0E−03	0.60	2.5E−02	Triangular	See D.4.7
Operating Days	OD	days/year	250	225	300	250	Triangular	See D.4.8
Container Size	V_{cont}	gal	5.0	5.0	20	5.0	Triangular	See D.4.9
Container Residual Loss Fraction	$F_{cont\_residue}$	kg/kg	3.0E−03	3.0E−04	6.0E−03	3.0E−03	Triangular	See D.4.10
Fraction of DBP Lost During Sampling – 1 (Q_{DBP_day} <50 kg/site-day)	$F_{sampling\_1}$	kg/kg	2.0E−03	2.0E−03	2.0E−02	2.0E−02	Triangular	See D.4.11
Fraction of DBP Lost During Sampling – 2 (Q_{DBP_day} 50–200 kg/site-day)	$F_{sampling\_2}$	kg/kg	6.0E−04	6.0E−04	5.0E−03	5.0E−03	Triangular	See D.4.11
Fraction of DBP Lost During Sampling – 3 (Q_{DBP_day} 200–5,000 kg/site-day)	$F_{sampling\_3}$	kg/kg	5.0E−04	5.0E−04	4.0E−03	4.0E−03	Triangular	See D.4.11
Fraction of DBP Lost During Sampling – 4 (Q_{DBP_day} >5,000 kg/site-day)	$F_{sampling\_4}$	kg/kg	8.0E−05	8.0E−05	4.0E−04	4.0E−04	Triangular	See D.4.11
Transfer Efficiency Fraction	$F_{transfer\_eff}$	unitless	0.65	0.20	0.80	0.65	Triangular	See D.4.12
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/h	60	–	–	–	–	See D.4.13
Vapor Pressure at 25 °C	VP	mmHg	2.01E−05	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	278	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82.05	–	–	–	–	Universal constant
Density of DBP	RHO	kg/L	1.0	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1.0	–	–	–	–	Process parameter

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale / Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Equipment Cleaning Loss Fraction	$F_{equipment\_cleaning}$	kg/kg	2.0E−02	–	–	–	–	See D.4.14
Capture Efficiency for Spray Booth	$F_{capture\_eff}$	kg/kg	0.90	–	–	–	–	See D.4.15
Fraction of Solid Removed in Spray Mist	$F_{solidrem\_eff}$	kg/kg	1.0	–	–	–	–	See D.4.16

D.4.3 Production Volume

EPA estimated the total DBP production volume for paint and coating products using a uniform distribution with a lowerbound of 99,157 kg/year and an upperbound of 2,140,323 kg/year. This range is based on DBP CDR data of site production volumes, national aggregate production volumes, and percentages of the production volumes going to various industrial sectors (U.S. EPA, 2020a).

There were two reporters that reported to CDR for use of DBP in adhesive/sealant or paint/coating products: G.J. Chemical Co, Inc. in Somerset, New Jersey, who reported a volume of 139,618 lb; and MAK Chemicals in Clifton, NJ, who reported a use volume of 105,884 lb of DBP. This equates to a total known use volume of 245,502 lb of DBP; however, there is still a large portion of the aggregate PV range for DBP that is not attached to a known use.

According to CDR, the national aggregate PV range for manufacture and import of DBP in 2019 was between 1,000,000 to 10,000,000 lb. The total known production volumes for all uses add to 808,295 lb (562,794 lb not associated with use of adhesives/sealants or paints and coatings). Due to uncertainty in the expected use of DBP and the number of identified products for these uses, EPA assumed that the remaining PV with unknown use is split between the use of adhesives and sealants and paint and coating products (See Table_Apx D-7). Subtracting the known use PV that are not associated with adhesives/sealants/paints/coatings from the aggregate national PV range equates to a range of

- Low-end: 1,000,000 lb to 562,793 lb = 437,207 lb (198,314 kg); and
- High-end: 10,000,000 lb to 562,793 lb = 9,437,207 lb (4,280,645 kg).

EPA assumed half this PV is used in paints and coatings while the other half is used in adhesives and sealants. This results in a PV range of 99,157 to 2,140,323 kg/year across all sites for this use.

D.4.4 Number of Sites

Per 2020 U.S. Census Bureau data for the NAICS codes identified in the Emission Scenario Document on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a), Emission Scenario Document on the Coating Industry (Paints, Lacquers, and Varnishes) (OECD, 2009c), and Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating (OECD, 2011b), there are 83,456 paints and coatings use sites (U.S. BLS, 2023). Therefore, this value is used as a bounding limit, not to be exceeded by the calculation. Number of sites is calculated using the following equation:

Equation_Apx D-23.

$$N_s = \frac{PV}{Q_{DBP\_year}}$$

Where:

N_s	=	Number of sites (sites)
PV	=	Production volume of DBP (kg/year)
Q_{DBP_year}	=	Facility annual throughput of DBP (see Appendix D.4.5) (kg/site-year)

D.4.5 Throughput Parameters

The annual site throughput of paint and coating product is modeled using a triangular distribution with a lower-bound of 946 kg/site-year, an upper-bound of 446,600 kg/site-year, and mode of 5,704 kg/site-year. The upper-bound is based on the Generic Scenario for Spray Coatings in the Furniture Industry (U.S. EPA, 2004d), which provides a range of 5,000 to 446,600 L of furniture coatings used per year based on plant size, with an assumption of 1 kg/L as the density of the coating. The mode is based on the default use rate for coating products from the Emission Scenario Document on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a). The ESD provides a default site use rate for a coating product as 1,505 gal/site-year, which is converted to 5,704 kg/site-year using an assumption of 1 kg/L for product density. The lower-bound is based on a summary table of available use rates in the Emission Scenario Document on Coating Application via Spray-Painting in the Automotive Refinishing Industry (OECD, 2011a). EPA selected a lower-bound from this table of 1 gallon of coating product used per site for 250 days/year (*e.g.*, 250 gallons/site-year or 946 L/site-year) and an assumption of 1 kg/L for product density.

The annual throughput of DBP in the Application of paints and coatings OES is calculated using Equation_Apx D-24 by multiplying the annual throughput of all paints and coatings by the concentration of DBP found in the paints and coatings.

Equation_Apx D-24.

$$Q_{DBP\_year} = Q_{coat\_year} * F_{DBP}$$

Where:

Q_{BBP_year}	=	Facility annual throughput of DBP (kg/site-year)
Q_{coat_year}	=	Facility annual throughput of all paints/coatings (kg/site-year)
F_{BBP}	=	Concentration of DBP in paints/ coatings (see Appendix D.4.7) (kg/kg)

The daily throughput of DBP is calculated using Equation_Apx D-25 by dividing the annual throughput by the number of operating days. The number of operating days is determined according to Appendix D.4.8.

Equation_Apx D-25.

$$Q_{DBP\_day} = \frac{Q_{DBP\_year}}{OD}$$

Where:

Q_{DBP_day}	=	Facility daily throughput of DBP (kg/site-day)
Q_{DBP_year}	=	Facility annual throughput of DBP (kg/site-year)
OD	=	Operating days (see Appendix D.4.8) (days/year)

D.4.6 Number of Containers per Year

The number of solid DBP-containing coating additive containers received and unloaded by a site per year is calculated using the following equation:

Equation_Apx D-26.

$$N_{cont\_unload\_year} = \frac{Q_{coat\_year}}{RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

$N_{cont\_unload\_year}$	=	Annual number of containers unloaded (container/site-year)
Q_{coat_year}	=	Facility annual throughput of all paints/coatings (kg/site-year)
RHO	=	DBP density (kg/L)

V_{cont} = Container volume (see Appendix D.4.9) (gal/container)

D.4.7 Paint/Coating DBP Concentration

EPA modeled DBP concentrations in the final paint and coating products using compiled SDS information (see Appendix E for EPA identified DBP-containing products for this OES). EPA assumed a triangular distribution with a lower-bound of 0.1 percent, upper-bound of 10 percent, and mode of 2.5 percent. The lower and upper bounds represent the minimum and maximum reported concentrations in the SDSs. The mode represents the mode of the upper-bound of the range endpoints reported in the SDSs.

D.4.8 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower-bound of 225 days/year, an upper-bound of 300 days/year, and a mode of 250 days/year. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 225 and 300 days/year. The lower-bound is based on ESIG's Specific Environmental Release Category Factsheet for Industrial Application of Coatings by Spraying (ESIG, 2020a), which estimates 225 days/year as the number of emission days. The upper-bound is based on the European Risk Report for DBP (ECB, 2004), which provided a default of 300 days/year. The mode is based on the Generic Scenario for Automobile Spray Coating (U.S. EPA, 1996), which estimates 250 days/year, based on 5 days/week operation that takes place 50 weeks/year.

D.4.9 Container Size

Based on identified products, EPA assumed that sites would receive paints and coatings in small containers (see Appendix E for a list of the DBP-containing products identified for this OES). According to the ChemSTEER User Guide, small containers are defined as containing between 5 and 20 gallons of material with a default size of 5 gallons (U.S. EPA, 2015). EPA modeled container size using a triangular distribution with a lower-bound of 5 gallons, an upper-bound of 20 gallons, and a mode of 5 gallons based on the defaults defined by the ChemSTEER User Guide.

D.4.10 Small Container Residue Loss Fraction

EPA used data from the PEI Associates Inc. study (Associates, 1988) for emptying drums by pouring along with central tendency and high-end values from the EPA/OPPT Small Container Residual Model. For unloading drums by pouring in the PEI Associates Inc. study (Associates, 1988), EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.03 to 0.79 percent and an average of 0.32 percent. The EPA/OPPT Small Container Residual Model from the ChemSTEER User Guide (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution, since triangular distributions require the least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the EPA/OPPT Small Container Residual Model in the ChemSTEER User Guide (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pouring.

D.4.11 Sampling Loss Fraction

Sampling loss fractions were estimated using the March 2023 Methodology for Estimating Environmental Releases from Sampling Wastes (U.S. EPA, 2023c). In this methodology, EPA completed a search of over 300 IRERs completed in the years 2021 and 2022 for sampling release data, including a similar proportion of both PMNs and LVEs. Of the searched IRERs, 60 data points for sampling release loss fractions, primarily for sampling releases from submitter-controlled sites (≈75% of IRERs), were obtained. The data points were analyzed as a function of the chemical daily throughput and industry type. This analysis showed that the sampling loss fraction generally decreased as the chemical daily throughput increased. Therefore, the methodology provides guidance for selecting a loss fraction based on chemical daily throughput. Table_Apx D-10 presents a summary of the chemical daily throughputs and corresponding loss fractions.

Table_Apx D-10. Sampling Loss Fraction Data from the March 2023 Methodology for Estimating Environmental Releases from Sampling Waste

Chemical Daily Throughput (kg/site-day) ($Q_{chem\_site\_day}$)	Number of Data Points	Sampled Quantity (kg chemical/day)		Sampling Loss Fraction ($LF_{sampling}$)	
		50th Percentile	95th Percentile	50th Percentile	95th Percentile
<50	13	0.03	0.20	0.002	0.02
50 to <200	10	0.10	0.64	0.0006	0.005
200 to <5,000	25	0.37	3.80	0.0005	0.004
≥5,000	10	1.36	6.00	0.00008	0.0004
All	58	0.20	5.15	0.0005	0.008

For each range of daily throughputs, EPA estimated sampling loss fractions using a triangular distribution of the 50th percentile value as the lower-bound, and the 95th percentile value as the upper-bound and mode. The sampling loss fraction distribution was chosen based on the calculation of daily throughput, as shown in Appendix D.4.5.

D.4.12 Transfer Efficiency Fraction

EPA modeled paint and coating spray application transfer efficiency fraction using a triangular distribution with a lower-bound of 0.2, an upper-bound of 0.8, and a mode of 0.65. The lower-bound and mode are based on the EPA/OPPT Automobile OEM Overspray Loss Model. Per the model, the transfer efficiency varies based on the type of spray gun used. For high volume, low pressure (HVLP) spray guns, the default transfer efficiency is 0.65. For conventional spray guns, the default transfer efficiency is 0.2 by mass. Across all spray technologies, the ESD on Coating Industry (OECD, 2009c) estimates a transfer efficiency of 30 to 80 percent. Therefore, EPA used 0.8 as the upper-bound.

D.4.13 Container Unloading Rate

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

D.4.14 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. This mode, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

D.4.15 Capture Efficiency for Spray Booth

The Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating (OECD, 2011b) uses the EPA/OPPT Automobile Refinish Coating Overspray Loss Model to estimate releases from spray coating. This model assumes a spray booth capture efficiency of 90 percent.

D.4.16 Fraction of Solid Removed in Spray Mist

The Emission Scenario Document on the Application of Radiation Curable Coatings, Inks, and Adhesives via Spray, Vacuum, Roll, and Curtain Coating (OECD, 2011b) uses the EPA/OPPT Automobile Refinish Coating Overspray Loss Model to estimate releases from spray coating. The model assumes both a capture efficiency and a solid removal efficiency for spray booths. The solid removal efficiency refers to the fraction of overspray material that is disposed to incineration or landfill after being captured. This model assumes a solid removal efficiency of 100 percent.

D.5 Use of Laboratory Chemicals Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DBP during the Use of laboratory chemicals OES. This approach utilizes the Generic Scenario on Use of Laboratory Chemicals (U.S. EPA, 2023d) and CDR data (U.S. EPA, 2020a) combined with Monte Carlo simulation.

Based on the GS, EPA identified the following release sources from use of laboratory chemicals:

- Release source 1: Release from Transferring DBP from Transport Containers (Liquids Only)
- Release source 2: Dust Emissions from Transferring Powders Containing DBP (Solids Only)
- Release source 3: Releases from Transport Container Cleaning
- Release source 4: Release from Cleaning Containers Used for Volatile Chemicals (Liquids Only)
- Release source 5: Labware Equipment Cleaning
- Release source 6: Releases during Labware Cleaning (Liquids Only)
- Release source 7: Releases During Laboratory Analysis (Liquids Only)
- Release source 8: Releases from Laboratory Waste Disposal

Environmental releases for DBP during the use of laboratory chemicals are a function of DBP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: facility throughput, DBP concentrations, air speed, saturation factor, container size, control technology efficiency, loss fractions, and diameters of equipment openings. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

D.5.1 Model Equations

Table_Apx D-11 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the Use of laboratory chemicals OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix D.5.2. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx D-11. Models and Variables Applied for Release Sources in the Use of Laboratory Chemicals OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Release from Transferring DBP from Transport Containers (Liquids Only)	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 2: Dust Emissions from Transferring Powders Containing DBP (Solids Only)	EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Appendix D.1)	$Q_{DBP\_day\_S}$; $F_{dust\_generation}$; $F_{dust\_capture}$; $F_{dust\_control}$
Release source 3: Releases from Transport Container Cleaning	Small Container Residual Model or EPA/OPPT Solid Residuals in Transport Containers Model, based on physical form (Appendix D.1)	$Q_{DBP\_day\_L}$; $Q_{DBP\_day\_S}$; $F_{container\_residue-L}$; $F_{container\_residue-S}$; V_{cont}; RHO; F_{DBP-S}; F_{DBP-L}; Q_{cont_solid}; Q_{cont_liquid}
Release source 4: Release from Cleaning Containers Used for Volatile Chemicals (Liquids Only)	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 5: Labware Equipment Cleaning	EPA/OPPT Multiple Process Vessel Residual Model or EPA/OPPT Solids Residuals in Transport Container Model, based on physical form (Appendix D.1)	$Q_{DBP\_day\_L}$; $Q_{DBP\_day\_S}$; $F_{lab\_residue-L}$; $F_{lab\_residue-S}$
Release source 6: Releases during Labware Cleaning (Liquids Only)	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 7: Releases During Laboratory Analysis (Liquids Only)	Not assessed, release estimated using data from NEI and TRI	N/A
Release source 8: Releases from Laboratory Waste Disposal	See Equation_Apx D-27 and Equation_Apx D-28	$Q_{DBP\_day\_L}$; $Q_{DBP\_day\_S}$; $F_{container\_residue-S}$; $F_{container\_residue-L}$; $F_{lab\_residue-S}$; $F_{lab\_residue-L}$; $F_{dust\_generation}$; Release Points 1, 6, and 7

For liquid DBP, release source 8 (Laboratory Waste Disposal) is calculated via a mass-balance, using the following equation:

Equation_Apx D-27.

$$Release\_perDay_{RP8-L} = \left(Q_{DBP\_day\_L} - Release\_perDay_{RP1} - Release\_perDay_{RP6} - Release\_perDay_{RP7}\right) * \left(1 - F_{container\_residue-L} - F_{lab\_residue-L}\right)$$

Where:

$Release\_perDay_{RP8-L}$ = Liquid DBP released for release source 8 (kg/site-day)
$Q_{DBP\_day\_L}$ = Facility throughput of DBP (see Appendix D.5.3) (kg/site-day)
$Release\_perDay_{RP1}$ = Liquid DBP released for release source 1 (kg/site-day)

$Release\_perDay_{RP6}$	=	Liquid DBP released for release source 6 (kg/site-day)
$Release\_perDay_{RP7}$	=	Liquid DBP released for release source 7 (kg/site-day)
$F_{container\_residue-L}$	=	Fraction of DBP remaining in container as residue (see Appendix D.5.9) (kg/kg)
$F_{lab\_residue-L}$	=	Fraction of DBP remaining in lab equipment (see Appendix D.5.12) (kg/kg)

For solids containing DBP, release source 8 (Laboratory Waste Disposal) is calculated via a mass-balance, via the following equation:

Equation_Apx D-28.

$$Release\_perDay_{RP8-S} = Q_{DBP\_day\_S} * \left(1 - F_{dust\_generation} - F_{container\_residue-S} - F_{lab\_residue\_S}\right)$$

Where:

$Release\_perDay_{RP8-S}$	=	Solid DBP released for release source 8 (kg/site-day)
$Q_{DBP\_day\_S}$	=	Facility throughput of DBP (see Appendix D.5.3) (kg/site-day)
$F_{dust\_generation}$	=	Fraction of DBP lost during unloading of solid powder (see Appendix D.5.10) (kg/kg)
$F_{container\ residue-S}$	=	Fraction of solid DBP remaining in transport containers (see Appendix D.5.9) (kg/kg)
$F_{lab\_residue\_S}$	=	Fraction of solid DBP remaining in lab equipment (see Appendix D.5.12) (kg/kg)

D.5.2 Model Input Parameters

Table_Apx D-12 summarizes the model parameters and their values for the Use of Laboratory Chemicals Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided following this table.

5839 **Table_Apx D-12. Summary of Parameter Values and Distributions Used in the Use of Laboratory Chemicals Model**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Production Volume	PV	kg/year	9.8E04	–	–	–	–	See D.5.3
Facility Throughput of Solid DBP	$Q_{stock\_site\_day\_S}$	g/site-day	255	3.0E−03	510	–	Uniform	See D.5.3
Facility Throughput of Liquid DBP	$Q_{stock\_site\_day\_L}$	mL/site-day	2,000	0.50	4,000	–	Uniform	See D.5.3
DBP Solid Lab Chemical Concentration	F_{DBP_solid}	kg/kg	3.0E−03	3.0E−03	0.2	3.0E−03	Triangular	See D.5.6
DBP Liquid Lab Chemical Concentration	F_{DBP_liquid}	kg/kg	1.0E−03	1.0E−03	0.1	1.0E−03	Triangular	See D.5.6
Operating Days	OD	days/year	365	–	–	–	–	See D.5.7
Liquid Container Size	V_{cont}	gal	1.0	0.50	1.0	1.0	Triangular	See D.5.8
Solid Container Size	Q_{cont_solid}	kg	1.0	0.5	1.0	1.0	Triangular	See D.5.8
Fraction of DBP Remaining in Container as Residue – Solid	$F_{container\_residue\text{-}solid}$	kg/kg	1.0E−02	–	–	–	–	See D.5.9
Fraction of DBP Remaining in Container as Residue – Liquid	$F_{container\_residue\text{-}liquid}$	kg/kg	3.0E−03	3.0E−04	6.0E−03	3.0E−03	Triangular	See D.5.9
Fraction of chemical lost during transfer of solid powders	$F_{dust\_generation}$	kg/kg	5.0E−03	1.0E−03	3.0E−02	5.0E−03	Triangular	See D.5.10
Dust Capture Technology Efficiency	$F_{dust\_capture}$	kg/kg	0.95	0	1.0	0.95	Triangular	See D.5.10
Dust Control Technology Removal Efficiency	$F_{dust\_control}$	kg/kg	0.99	0	1.0	0.99	Triangular	See D.5.10
Vapor Pressure at 25 °C	VP	mmHg	2.0E−05	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	278	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82	–	–	–	–	Universal constant
Density of DBP	RHO	kg/L	1.0	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1.0	–	–	–	–	Process parameter

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Small Container Fill Rate	$RATE_{fill}$	containers/h	60	–	–	–	–	See D.5.11
Fraction of DBP Remaining in Container as Residue Lab Equipment – Liquid	$F_{lab\_residue\_L}$	kg/kg	2.0E−02	–	–	–	–	See D.5.12
Fraction of DBP Remaining in Container as Residue Lab Equipment – Solid	$F_{lab\_residue\_S}$	kg/kg	1.0E−02	–	–	–	–	See D.5.12

D.5.3 Production Volume and Throughput Parameters

No sites reported to CDR for use of DBP in laboratory chemicals. EPA estimated the total production volume (PV) for all sites of 215,415 lb/year (97,710 kg/year) that was estimated based on the reporting requirements for CDR. The threshold for CDR reporters requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year. For the 12 sites that reported to CDR for the manufacture or import of DBP, EPA assumed that each site used DBP for laboratory chemicals in volumes up to the reporting threshold limit of 5 percent of their reported PV. If 5 percent of each site's reported PV exceeded the 25,000 lb reporting limit, EPA assumed the site used only 25,000 lb annually as an upper-bound. If the site reported a PV that was CBI, EPA assumed the maximum PV contribution of 25,000 lb. The CDR sites and their PV contributions to this OES are shown in Table_Apx D-13.

Table_Apx D-13. CDR Reported Site Information for Use in Calculation of Laboratory Chemicals Production Volume

Site Name	Site Location	Reported Production Volume (lb/year)	Threshold Limit Used	Production Volume Added to Total (lb/year)
Huntsman Corporation – The Woodlands Corporate Site	The Woodlands, TX	CBI	25,000 lb	25,000
Covalent Chemical	Raleigh, NC	88,184	5%	4,409.2
Greenchem	West Palm Beach, FL	CBI	25,000 lb	25,000
Dystar LP	Reidsville, NC	51,852	5%	2,592.6
The Sherwin-Williams Company	Cleveland, OH	CBI	25,000 lb	25,000
GJ Chemical Co. Inc.	Newark, NJ	139,618	5%	6,908.9
Polymer Additives, Inc.	Bridgeport, NJ	CBI	25,000 lb	25,000
MAK Chemicals	Clifton, NJ	105,884	5%	5,294.2
Industrial Chemicals, Inc.	Vestavia Hills, AL	422,757	5%	21,137.85
Shrieve Chemical Company, LLC	Spring, TX	CBI	25,000 lb	25,000
2 sites marked as CBI	CBI	CBI	25,000 lb	50,000

The Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases (U.S. EPA, 2023d) provides daily throughput of DBP required for laboratory stock solutions. According to the GS, laboratory liquid use rates range from 0.5 mL up to 4 L per day, and laboratory solid use rates range from 0.003 to 510 g per day. Laboratory stock solutions are used for multiple analyses and eventually need to be replaced. The expiration or replacement times range from daily to 6 months (U.S. EPA, 2023d). For this scenario, EPA assumes stock solutions are prepared daily per the GS. EPA assigned a uniform distribution for the daily throughput of laboratory stock solutions with upper- and lower-bounds corresponding to the high and low use rates, respectively.

The daily throughput of DBP in liquid laboratory chemicals is calculated using Equation_Apx D-29 by multiplying the daily throughput of all laboratory solutions by the concentration of DBP in the solutions and converting volume to mass.

Equation_Apx D-29.

$$Q_{DBP\_day\_L} = Q_{stock\_site\_day\_L} * F_{DBP-L} * RHO * \frac{0.001L}{mL}$$

Where:

$Q_{DBP\_day\_L}$	=	Facility daily throughput of liquid DBP (kg/site-day)
$Q_{stock\_site\_day\_L}$	=	Facility annual throughput of liquid laboratory chemicals (mL/site-day)
F_{DBP-L}	=	Concentration of DBP in liquid laboratory chemicals (see Appendix D.5.6) (kg/kg)
RHO	=	Density of DBP (kg/L)

The daily throughput of DBP in solid laboratory chemicals is calculated using Equation_Apx D-30 by multiplying the daily throughput of all laboratory solids by the concentration of DBP in the solids.

Equation_Apx D-30.

$$Q_{DBP\_day\_S} = Q_{stock\_site\_day\_S} * F_{DBP-S} * \frac{0.001kg}{g}$$

Where:

$Q_{DBP\_day\_S}$	=	Facility daily throughput of solid DBP (kg/site-day)
$Q_{stock\_site\_day\_S}$	=	Facility annual throughput of solid laboratory chemicals (g/site-day)
F_{DBP-S}	=	Concentration of DBP in solid laboratory chemicals (see Appendix D.5.6) (kg/kg)

To avoid cases where the number of sites is greater than the bounding estimate of 36,873 sites (see Appendix D.5.4), EPA calculated an adjusted value for the daily throughput of DBP. If the number of sites is less than the bounding estimate, then the adjusted facility throughput of DBP will be the same as the facility throughput calculated in Equation_Apx D-30. Otherwise, the adjusted facility throughput is calculated using Equation_Apx D-31 by dividing the facility production rate by the maximum number of sites and operating days. The number of operating days is determined according to Appendix D.5.7.

Equation_Apx D-31.

$$Q_{DBP\_day\_adj} = \frac{PV}{N_s * OD}$$

$Q_{DBP\_day\_adj}$	=	Adjusted daily facility throughput of DBP (kg/site-day)
N_s	=	Maximum number of sites (see Appendix D.5.4) (sites)
PV	=	Facility production rate of DBP in laboratory chemicals (see Appendix D.5.3) (kg/kg)
OD	=	Operating days (see Appendix D.5.7) (days/site-year)

D.5.4 Number of Sites

Per 2020 U.S. Census Bureau data for the NAICS codes identified in the Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases (U.S. EPA, 2023d), there are 36,873 laboratory chemical use sites (U.S. BLS, 2023). Therefore, this value is used as a bounding limit, not to be exceeded by the calculation. Number of sites is calculated using a per-site throughput and DBP production volume with the following equation:

Equation_Apx D-32.

$$N_s = \frac{PV}{Q_{DBP_{day}} * OD}$$

Where:

N_s	=	Number of sites (sites)
PV	=	Production volume of DBP (kg/year)
Q_{DBP_day}	=	Facility daily throughput of DBP (kg/site-day)
OD	=	Operating days (see Appendix D.5.7) (days/site-year)

D.5.5 Number of Containers per Year

The number of liquid DBP laboratory containers unloaded by a site per year is calculated using the following equation:

Equation_Apx D-33.

$$N_{cont\_unload\_year} = \frac{Q_{DBP\_day\_L} * OD}{F_{DBP-L} * RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

$N_{cont\_unload\_year}$	=	Annual number of containers unloaded (container/site-year)
$Q_{DBP\_day\_L}$	=	Facility daily throughput of liquid DBP (kg/site-day)
OD	=	Operating days (see Appendix D.5.7) (days/site-year)
F_{DBP-L}	=	Mass fraction of DBP in liquid (see Appendix D.5.6) (kg/kg)
RHO	=	DBP density (kg/L)
V_{cont}	=	Container volume (see Appendix D.5.8) (gal/container)

The number of laboratory containers containing solids with DBP unloaded by a site per year is calculated using the following equation:

Equation_Apx D-34.

$$N_{cont\_unload\_year} = \frac{Q_{DBP\_day\_S} * OD}{F_{DBP-S} * Q_{cont\_solid}}$$

Where:

$N_{cont\_unload\_year}$	=	Annual number of containers unloaded (container/site-year)
$Q_{DBP\_day\_S}$	=	Facility daily throughput of solid DBP (kg/site-day)
OD	=	Operating days (see Appendix D.5.7) (days/site-year)
F_{DBP-S}	=	Mass fraction of DBP in solids (see Appendix D.5.6) (kg/kg)
Q_{cont_solid}	=	Mass in container of solids (see Appendix D.5.8) (kg/container)

D.5.6 DBP Concentration in Laboratory Chemicals

EPA modeled DBP concentration in liquid laboratory chemicals using SDS concentrations for four liquid lab products. EPA modeled concentrations using a triangular distribution with a lower-bound of 0.1 percent, an upper-bound of 10 percent, and a mode of 0.1 percent. For solid laboratory chemicals, EPA modeled concentrations using a triangular distribution with a lower-bound of 0.3 percent, upper-bound of 20 percent, and mode of 0.3 percent, based on the concentration ranges reported in four SDSs found for solid laboratory chemicals. The lower- and upper-bounds represent the minimum and maximum reported concentrations in the SDSs for both liquid and solid laboratory chemicals. The mode represents the median of all high-end range endpoints reported in the SDSs (see Appendix E for EPA-identified, DBP-containing products for this OES).

D.5.7 Operating Days

Two sites reporting to NEI for the use of DBP in laboratory chemicals reported air releases occurring over 365 days/year. EPA was unable to identify additional specific information for operating days for the use of DBP in laboratory chemicals. Therefore, EPA assumed that the operating days for laboratories would be 365 days per year (U.S. EPA, 2023a, 2019).

D.5.8 Container Size

The Use of Laboratory Chemicals – Generic Scenario for Estimating Occupational Exposures and Environmental Releases (U.S. EPA, 2023d) states that, in the absence of site-specific information, a default liquid volume of 1 gallon and a default solid quantity of 1 kg may be used. Laboratory products containing DBP showed container sizes less than 1 gallon or 1 kg. Based on model assumptions of site daily throughput, EPA decided to allow for a lower-bound of 0.5 gallon or 0.5 kg to account for smaller container sizes while maintaining the daily number of containers unloaded per site at a reasonable value. Therefore, EPA built a triangular distribution for liquid volumes with a lower-bound of 0.5 gallon and an upper-bound and mode of 1 gallon. EPA similarly built a triangular distribution for solid quantities with a lower-bound of 0.5 kg and an upper-bound and mode of 1 kg.

D.5.9 Container Loss Fractions

EPA used data from the PEI Associates Inc. study (Associates, 1988) for emptying drums by pouring along with central tendency and high-end values from the EPA/OPPT Small Container Residual Model. For unloading drums by pouring in the PEI Associates Inc. study (Associates, 1988), EPA found that the average percent residual from the pilot-scale experiments showed a range of 0.03 percent to 0.79 percent and an average of 0.32 percent. The EPA/OPPT Small Container Residual Model from the ChemSTEER User Guide (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution because triangular distributions require the least assumptions and are completely defined by range and mode of a parameter. EPA assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the EPA/OPPT Small Container Residual Model in the ChemSTEER User Guide (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pouring.

For solid containers, EPA used the EPA/OPPT Solid Residuals in Transport Containers Model to estimate residual releases from solid container cleaning. The EPA/OPPT Solid Residuals in Transport Containers Model, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015) provides an overall loss fraction of 1 percent from container cleaning.

D.5.10 Dust Generation Loss Fraction, Dust Capture Efficiency, and Dust Control Efficiency

The EPA/OPPT Generic Model to Estimate Dust Releases from Transfer/Unloading/Loading Operations of Solid Powders (Dust Release Model) compiled data for loss fractions of solids from various sources in addition to the capture and removal efficiencies for control technologies in order to estimate releases of dust to the environment during transfer operations. Dust releases estimated from the model are based on three different parameters: the initial loss fraction, the fraction captured by the capture technology, and the fraction removed/controlled by the control technology. The underlying distributions for each of these parameters is not known; therefore, EPA assigned triangular distributions because a triangular distribution requires least assumptions and is completely defined by range and mode of a parameter.

EPA assigned the range and mode for each of the three parameters using the data presented in the Dust Release Model. For the initial loss fraction, the Agency assigned a range of 6.0×10^{-6} to 0.045 with a mode of 0.005 by mass. EPA assigned the mode based on the recommended default value for the parameter in the Dust Release Model. The range of initial loss fraction values comes from the range of values compiled from various sources and considered in the development of the Dust Release Model (U.S. EPA, 2021b).

For the fraction of dust captured, EPA assigned a range of 0 to 1.0 with a mode of 0.95 by mass. EPA assigned the range for the fraction captured based on the minimum and maximum estimated capture efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction captured based on the capture efficiency for laboratory fume hoods because the Agency expects that capture technology will likely be used.

For the fraction of captured dust that is removed/controlled, EPA assigned a range of 0 to 1.0 with a mode of 0.99 by mass. The Agency assigned the range for the fraction controlled based on the minimum and maximum estimated control efficiencies listed in the data compiled for the Dust Release Model. EPA assigned the mode for the fraction controlled based on control efficiency for filtering systems.

D.5.11 Small Container Fill Rate

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

D.5.12 Equipment Cleaning Loss Fraction

For liquids, EPA used the EPA/OPPT Multiple Process Residual Model to estimate the releases from equipment cleaning. This model, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015), provides an overall loss fraction of 2 percent from equipment cleaning.

For solids, used the EPA/OPPT Solid Residuals in Transport Containers Model to estimate the releases from equipment cleaning. This model, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015)m provides an overall loss fraction of 1 percent from equipment cleaning.

D.6 Use of Lubricants and Functional Fluids Model Approach and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DBP during the Use of lubricants and functional fluids OES. This approach utilizes the Emission Scenario Document on Lubricants and Lubricant Additives (OECD, 2004b) combined with Monte Carlo simulation.

Based on the ESD, EPA identified the following release sources from the use of lubricants and functional fluids:

- Release source 1: Release During the Use of Equipment
- Release source 2: Release During Changeout of Lubricants and Functional Fluids

Environmental releases for DBP during the use of lubricants and fluids are a function of DBP's physical properties, container size, mass fractions, and other model parameters. While physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: production volume, DBP concentrations, product density, container size, loss fractions, and operating days. EPA used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

D.6.1 Model Equations

Table_Apx D-14 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the Use of lubricants and fluids OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix D.6.2. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx D-14. Models and Variables Applied for Release Sources in the Use of Lubricants and Functional Fluids OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Release During the Use of Equipment	See Equation_Apx D-35 through Equation_Apx D-39	Q_{DBP_day}; LF_{land_use}; LF_{water_use}
Release source 2: Release During Changeout of Lubricants and Functional Fluids	See Equation_Apx D-35 through Equation_Apx D-39	Q_{DBP_day}; $LF_{land\_disposal}$; $LF_{water\_disposal}$

Release source 1 (Release During the Use of Equipment) and 2 (Release During Changeout) are partitioned out by release media. Loss fractions are described in the model parameter sections below. For both water and land media, release 1 is then calculated using the following equation:

Equation_Apx D-35.

$$Release\_perDay_{RP1\_land/water} = Q_{DBP\_day} * \left(LF_{land\_use} + LF_{water\_use}\right)$$

Where:

$Release\_perDay_{RP1\_land/water}$	=	DBP loss to land/water for release source 1 (kg/site-day)
Q_{DBP_day}	=	Facility throughput of DBP (see Appendix D.6.3) (kg/site-day)
LF_{land_use}	=	Loss fraction to land during the use of equipment (see Appendix D.6.7) (unitless)
LF_{water_use}	=	Loss fraction to water during the use of equipment (see Appendix D.6.7) (unitless)

A similar equation is used to calculate release 2 to water and land:

Equation_Apx D-36.

$$Release\_perDay_{RP2\_land/water} = Q_{DBP\_day} * \left(LF_{land\_disposal} + LF_{water\_disposal}\right)$$

Where:

$Release\_perDay_{RP2\_land/water}$	=	DBP loss to land/water for release source 2 (kg/site-day)
Q_{DBP_day}	=	Facility throughput of DBP (see Appendix D.6.3) (kg/site-day)
$LF_{land\_disposal}$	=	Loss fraction to land during lubricant disposal (see Appendix D.6.7) (unitless)
$LF_{water\_disposal}$	=	Loss fraction to water during lubricant disposal (see Appendix D.6.7) (unitless)

If the sum of LF_{land_use}, LF_{water_use}, $LF_{land\_disposal}$, and $LF_{water\_disposal}$ exceeds 100 percent, EPA creates adjusted loss fractions based on weighted contributions to equal exactly 100 percent. The releases per day are then recalculated using the adjusted loss fractions. For example, the adjusted land use loss fraction would be calculated using the following equation:

Equation_Apx D-37.

$$LF_{land\_use\_adjusted} = \frac{LF_{land\_use}}{\left(LF_{land\_use} + LF_{water\_use} + LF_{land\_disposal} + LF_{water\_disposal}\right)}$$

Where:

$LF_{land\_use\_adjusted}$	=	Adjusted loss fraction to land during the use of equipment (unitless)
LF_{land_use}	=	Loss fraction to land during the use of equipment (see Appendix D.6.7) (unitless)
LF_{water_use}	=	Loss fraction to water during the use of equipment (see Appendix D.6.7) (unitless)
$LF_{land\_disposal}$	=	Loss fraction to land during lubricant disposal (see Appendix D.6.7) (unitless)
$LF_{water\_disposal}$	=	Loss fraction to water during lubricant disposal (see Appendix D.6.7) (unitless)

Finally, EPA will assess any DBP not released to the environment after accounting for release sources 1 and 2 as going to recycling and fuel blending (incineration). If all DBP is released during release sources 1 and 2, then the release to recycling and fuel blending will not be calculated. The following equations are used to calculate the amount of remaining DBP sent for recycling and fuel blending:

Equation_Apx D-38.

$$\begin{aligned} Release\_perDay_{RP2\_recycle} &= \Big(Q_{DBP\_day} - {Release_{perDay}}_{RP1\_land} - {Release_{perDay}}_{RP1\_water-} {Release_{perDay}}_{RP2\_land} \\ &\quad - Release\_perDay_{RP2\_water}\Big) * F_{waste\_recycle} \end{aligned}$$

Equation_Apx D-39.

$$Release\_perDay_{RP2\_fuel\_blend} = \left(Q_{DBP\_day} - Release_{perDay}{}_{RP1\_land} - Release_{perDay}{}_{RP1\_water-}Release_{perDay}{}_{RP2\_land} - Release\_perDay_{RP2\_water}\right) * F_{waste\_incineration}$$

Where:

$Release\_perDay_{RP2\_recycle}$	=	DBP recycled (kg/site-day)
$Release\_perDay_{RP2\_fuel\_blend}$	=	DBP sent for fuel blending (kg/site-day)
Q_{DBP_day}	=	Facility throughput of DBP (see Appendix D.6.3) (kg/site-day)
$Release\_perDay_{RP1\_land}$	=	DBP released for release source 1 to land (kg/site-day)
$Release\_perDay_{RP1\_water}$	=	DBP released for release source 1 to water (kg/site-day)
$Release\_perDay_{RP2\_land}$	=	DBP released for release source 2 to land (kg/site-day)
$Release\_perDay_{RP2\_water}$	=	DBP released for release source 2 to water (kg/site-day)
$F_{waste\_recycle}$	=	Fraction of DBP that goes to recycling (see Appendix D.6.8) (kg/kg)
$F_{waste\_incineration}$	=	Fraction of DBP that goes to fuel blending (see Appendix D.6.9) (kg/kg)

D.6.2 Model Input Parameters

Table_Apx D-15 summarizes the model parameters and their values for the Use of Lubricants and Fluids Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after this table.

6148 **Table_Apx D-15. Summary of Parameter Values and Distributions Used in the Use of Lubricants and Functional Fluids Model**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/ Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Total Production Volume of DBP at All Sites	PV_{total}	kg/year	9.8E04	–	–	–	–	See D.6.3
Mass Fraction of DBP in Product	F_{DBP}	kg/kg	7.5E−02	1.0E−05	7.5E−02	–	Uniform	See D.6.4
Density of DBP-based Products	$RHO_{product}$	kg/m^3	900	840	1,000	900	Triangular	See D.6.4
Operating Days	OD	days/year	4	1	4	–	Uniform	See D.6.5
Container Size	V_{cont}	gal	55	20	330	55	Triangular	See D.6.6
Loss Fraction to Land During Use	LF_{land_use}	kg/kg	0.16	1.4E−02	0.16	–	Uniform	See D.6.7
Loss Fraction to Water During Use	LF_{water_use}	kg/kg	0.45	3.0E−03	0.45	–	Uniform	See D.6.7
Loss Fraction to Land During Disposal	$LF_{land\_disposal}$	kg/kg	0.30	1.0E−02	0.30	–	Uniform	See D.6.7
Loss Fraction to Water During Disposal	$LF_{water\_disposal}$	kg/kg	0.37	0.23	0.37	–	Uniform	See D.6.7
Percentage of Waste to Recycling	$F_{waste\_recycle}$	kg/kg	4.3E−02	–	–	–	–	See D.6.8
Percentage of Waste to Fuel Blending	$F_{waste\_incineration}$	kg/kg	0.96	–	–	–	–	See D.6.9

6149

D.6.3 Production Volume and Throughput Parameters

No sites reported to CDR for use of DBP in lubricants or functional fluids. EPA estimated the total production volume (PV) for all sites assuming a static value of 215,415 lb/year (97,710 kg/year) that was estimated based on the reporting requirements for CDR. The threshold for CDR reporters requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year. For the 12 sites that reported to CDR for the manufacture or import of DBP, EPA assumed that each site used DBP for laboratory chemicals in volumes up to the reporting threshold limit of 5 percent of their reported PV. If 5 percent of each site's reported PV exceeds the 25,000 lb reporting limit, EPA assumed the site used only 25,000 lb annually as an upper-bound. If the site reported a PV that was CBI, EPA assumed the maximum PV contribution of 25,000 lb. The CDR sites and their PV contributions to this OES are shown in Table_Apx D-13.

Product throughput is calculated by converting container volume to mass using the product density and multiplying by operating days. Equation_Apx D-40 assumes that each site uses one container of product each day. Container size is determined according to Appendix D.6.6. Product density is determined according to Appendix D.6.4. Operating days are determined according to Appendix D.6.5.

Equation_Apx D-40.

$$Q_{product\_year} = V_{cont} * 0.00379 \frac{m^3}{gal} * RHO_{product} * OD$$

Where:

$Q_{product\_year}$	=	Facility annual throughput of lubricant/fluid (kg/site-year)
V_{cont}	=	Container size (see Appendix D.6.6) (gal)
$RHO_{product}$	=	Product density (see Appendix D.6.4) (kg/m^3)
OD	=	Operating days (see Appendix D.6.5) (days/year)

The annual throughput of DBP is calculated using Equation_Apx D-41 by multiplying product annual throughput by the concentration of DBP in the product. The concentration of DBP in the product is determined according to Appendix D.6.4.

Equation_Apx D-41.

$$Q_{DBP\_year} = Q_{product\_year} * F_{DBP}$$

Where:

Q_{DBP_year}	=	Facility annual throughput of DBP (kg/site-year)
$Q_{product\_year}$	=	Facility annual throughput of lubricant/fluid (kg/site-year)
F_{DBP}	=	Concentration of DBP in lubricant/fluid (see Appendix D.6.4) (kg/kg)

The daily throughput of DBP is calculated using by dividing the annual production volume by the number of operating days. The number of operating days is determined according to Appendix D.6.5.

Equation_Apx D-42.

$$Q_{DBP\_day} = \frac{Q_{DBP\_year}}{OD}$$

Where:

Q_{DBP_day}	=	Facility throughput of DBP (kg/site-day)
Q_{DBP_year}	=	Facility annual throughput of DBP (kg/site-year)
OD	=	Operating days (see Appendix D.6.5) (days/year)

D.6.4 Mass Fraction of DBP in Lubricant/Fluid and Product Density

EPA modeled DBP mass fraction in lubricants and fluids using a uniform distribution with a lower-bound of 0.001 percent and an upper-bound of 7.5 percent. EPA modeled product density using a triangular distribution with a lower-bound of 840 kg/m^3, an upper-bound of 1,000 kg/m^3, and a mode of 900 kg/m^3. EPA was not able to identify products for this use that contained DBP. For that reason, EPA based the concentration and density estimates on compiled SDS information for lubricants and fluids containing DIDP and assumed that DBP-containing lubricants and fluids would have similar concentrations and density ranges. The DIDP-containing product are identified in Appendix F of the *Environmental Release and Occupational Exposure Assessment for Diisodecyl Phthalate (DIDP)* (U.S. EPA, 2024c).

D.6.5 Operating Days

EPA modeled operating days per year using a uniform distribution with a lower-bound of 1 day/year and an upper-bound of 4 days/year. To ensure that only integer values of this parameter were selected, EPA nested the uniform distribution probability formula within a discrete distribution that listed each integer between (and including) 1 to 4 days/year. Both bounds are based on the ESD on Lubricants and Lubricant Additives (OECD, 2004b). The ESD states that changeout rates for lubricant/functional fluids range from 3 to 60 months. This corresponds to one to four changeouts per year, which EPA assumes is equal to operating days. Where changeout frequency occurs over 12 months, EPA used a value one container per 12 months as a representative value.

D.6.6 Container Size

EPA modeled container size using a triangular distribution with a lower-bound of 20 gallons, an upper-bound of 330 gallons, and a mode of 55 gallons. This was based on SDS and technical data sheets for DIDP-containing lubricants, as lubricant products containing DBP were not identified. In this data, EPA identified lubricants in containers from less than 1 gallon to 330 gallons. The mode of the reported container sizes was 55 gallons; however, when running the model, smaller use rates produced an unreasonable number of use sites. Therefore, EPA assumed this to be an indication that it is unlikely that sites only have one small piece of equipment. Based on this and the remaining technical data, EPA selected 20 gallons as the lower-bound (U.S. EPA, 2024d).

D.6.7 Loss Fractions

The loss fractions to each release media for the use and disposal of lubricants are based on the ESD on Lubricants and Lubricant Additives (OECD, 2004b). The ESD provides multiple values for loss fractions to land and water. EPA used these values to build the uniform distributions for each loss fraction. For the use of lubricants, the ESD provided a range of 0.014 to 0.16 for loss fractions to land and 0.003 to 0.45 for loss fractions to water. For the disposal of lubricants, the ESD provided a range of 0.01 to 0.3 for loss fractions to land and 0.23 to 0.37 for loss fractions to water.

D.6.8 Percentage of Waste to Recycling

The ESD on Lubricants and Lubricant Additives (OECD, 2004b) estimates that 4.3 percent of all lubricant/functional fluids are recycled.

D.6.9 Percentage of Waste to Fuel Blending

The ESD on Lubricants and Lubricant Additives (OECD, 2004b) estimates that 95.7 percent of all lubricant/functional fluids are reused for fuel oil or other general incineration releases.

D.7 Use of Penetrants and Inspection Fluids Release Model Approaches and Parameters

This appendix presents the modeling approach and equations used to estimate environmental releases for DBP during the Use of penetrants and inspection fluids OES. This approach utilizes the Emission Scenario Document on the Use of Metalworking Fluids (OECD, 2011c) combined with Monte Carlo simulation. EPA assessed the environmental releases for this OES separately for non-aerosol penetrants and for aerosol-applied penetrants.

Based on the ESD, EPA identified the following release sources from the use of non-aerosol penetrants:

- Release source 1: Transfer Operation Losses to Air from Unloading Penetrant
- Release source 2: Container Cleaning Wastes
- Release source 3: Open Surface Losses to Air During Container Cleaning
- Release source 4: Equipment Cleaning Wastes
- Release source 5: Open Surface Losses to Air During Equipment Cleaning
- Release source 7: Disposal of Used Penetrant

Based on the ESD, EPA identified the following release sources from the use of aerosol-applied penetrants:

- Release source 2: Container Cleaning Wastes
- Release source 6: Aerosol Application of Penetrant

Environmental releases for DBP during the use of penetrants are a function of DBP's physical properties, container size, mass fractions, and other model parameters. Although physical properties are fixed, some model parameters are expected to vary. EPA used a Monte Carlo simulation to capture variability in the following model input parameters: DBP concentrations, air speed, saturation factor, container size, loss fractions, and operating days. EPA also used the outputs from a Monte Carlo simulation with 100,000 iterations and the Latin Hypercube sampling method in @Risk to calculate release amounts for this OES.

D.7.1 Model Equations

Table_Apx D-16 provides the models and associated variables used to calculate environmental releases for each release source within each iteration of the Monte Carlo simulation. EPA used these environmental releases to develop a distribution of release outputs for the Use of penetrants OES. The variables used to calculate each of the following values include deterministic or variable input parameters, known constants, physical properties, conversion factors, and other parameters. The values for these variables are provided in Appendix D.7.2. The Monte Carlo simulation calculated the total DBP release (by environmental media) across all release sources during each iteration of the simulation. EPA then selected 50th and 95th percentile values to estimate the central tendency and high-end releases, respectively.

Table_Apx D-16. Models and Variables Applied for Release Sources in the Use of Penetrants and Inspection Fluids OES

Release Source	Model(s) Applied	Variables Used
Release source 1: Transfer Operation Losses to Air from Unloading Penetrant	EPA/OAQPS AP-42 Loading Model (Appendix D.1)	Vapor Generation Rate: F_{DBP}; VP; f_{sat}; MW; R; T; V_{cont}; $RATE_{fill\_cont}$; $RATE_{fill\_drum}$ Operating Time: Q_{DBP_year} ; V_{cont}; OD; $RATE_{fill\_cont}$; $RATE_{fill\_drum}$; RHO; F_{DBP}
Release source 2: Container Cleaning Wastes	EPA/OPPT Drum Residual Model or EPA/OPPT Bulk Transport Residual Model, based on container size (Appendix D.1)	Q_{DBP_day}; LF_{drum}; LF_{cont}; V_{cont}; RHO; OD; F_{DBP}
Release source 3: Open Surface Losses to Air During Container Cleaning	EPA/OPPT Penetration Model or EPA/OPPT Mass Transfer Coefficient Model, based on air speed (Appendix D.1)	Vapor Generation Rate: F_{DBP}; MW; VP; $RATE_{air\_speed}$; D_{cont_clean}; T; P Operating Time: Q_{DBP_year} ; V_{cont}; OD; $RATE_{fill\_cont}$; $RATE_{fill\_drum}$; RHO; F_{DBP}
Release source 4: Equipment Cleaning Wastes	EPA/OPPT Multiple Process Vessel Residual Model (Appendix D.1)	Q_{DBP_day}; LF_{equip}
Release source 5: Open Surface Losses to Air During Equipment Cleaning	EPA/OPPT Penetration Model or EPA/OPPT Mass Transfer Coefficient Model, based on air speed (Appendix D.1)	Vapor Generation Rate: F_{DBP}; MW; VP; $RATE_{air\_speed}$; D_{equip_clean}; T; P Operating Time: OH_{equip_clean}
Release source 6: Aerosol Application of Penetrant	See Equation_Apx D-43 and Equation_Apx D-44	Q_{DBP_day}; $\%_{air}$; $\%_{uncertain}$; Release point 2
Release source 7: Disposal of Used Penetrant	See Equation_Apx D-45	Q_{DBP_day}; Release points 1 through 5

Release source 6 (Aerosol Application of Penetrant) is partitioned out by release media. In order to calculate the releases to each media, the total release is calculated first using the following equation:

Equation_Apx D-43.

$$Release\_perDay_{RP6} = Q_{DBP\_day} - Release\_perDay_{RP2}$$

Where:

$Release\_perDay_{RP6}$ = DBP released for release source 6 to all release media (kg/site-day)
Q_{DBP_day} = Facility throughput of DBP (see Appendix D.7.3) (kg/site-day)
$Release\_perDay_{RP2}$ = DBP released for release source 2 (kg/site-day)

Then, the release amounts to each media are calculated using the following equation:

Equation_Apx D-44.

$$Release\_perDay_{RP6\_media} = Release\_perDay_{RP6} * \%_{media}$$

Where:

$Release\_perDay_{RP6\_media}$	=	Amount of release 6 that is released to selected media (kg/site-day)
$Release\_perDay_{RP6}$	=	DBP released for release source 6 to all release media (kg/site-day)
$\%_{media}$	=	Percent of release 6 that is released to selected media (unitless)

Release source 7 (Disposal of Used Penetrant) is calculated via a mass-balance, via the following equation:

Equation_Apx D-45.

$$Release\_perDay_{RP7} = Q_{DBP\_day} - \sum_{i=1}^{5} Release\_perDay_{RPi}$$

Where:

$Release\_perDay_{RP7}$	=	DBP released for release source 7 (kg/site-day)
Q_{DBP_day}	=	Facility throughput of DBP (see Appendix D.7.3) (kg/site-day)
$\sum_{i=1}^{5} Release\_perDay_{RPi}$	=	The sum of release points 1 to 5 emissions (kg/site-day)

D.7.2 Model Input Parameters

Table_Apx D-17 summarizes the model parameters and their values for the Use of Penetrants and Inspection Fluids Monte Carlo simulation. Additional explanations of EPA's selection of the distributions for each parameter are provided after this table.

6319 **Table_Apx D-17. Summary of Parameter Values and Distributions Used in the Release Estimation of Penetrants and Inspection**
6320 **Fluids**

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Total Production Volume of DBP at All Sites	PV_{total}	kg/year	9.8E04	–	–	–	–	See D.7.3
Penetrant DBP Concentration	F_{DBP}	kg/kg	0.2	0.1	0.2	–	Uniform	See D.7.7
Operating Days	OD	days/year	247	246	249	247	Triangular	See D.7.8
Air Speed	$RATE_{air\_speed}$	ft/min	19.7	2.56	398	–	Lognormal	See D.7.9
Saturation Factor	f_{sat}	dimensionless	0.5	0.5	1.45	0.5	Triangular	See D.7.10
Container Size	V_{cont}	gal	0.082	0.082	55	0.082	Triangular	See D.7.11
Small Container Loss Fraction	LF_{cont}	kg/kg	0.003	0.003	0.006	0.003	Triangular	See D.7.12
Drum Residual Loss Fraction	LF_{drum}	kg/kg	0.025	0.017	0.03	0.025	Triangular	See D.7.12
Equipment Cleaning Loss Fraction	LF_{equip}	kg/kg	0.002	0.0007	0.01	0.002	Triangular	See D.7.13
Vapor Pressure at 25 °C	VP	mmHg	2.01E−05	–	–	–	–	Physical property
Molecular Weight	MW	g/mol	278	–	–	–	–	Physical property
Gas Constant	R	atm-cm^3/gmol-L	82	–	–	–	–	Universal constant
Density of DBP	RHO	kg/L	1.0	–	–	–	–	Physical property
Temperature	T	K	298	–	–	–	–	Process parameter
Pressure	P	atm	1	–	–	–	–	Process parameter
Small Container Fill Rate	$RATE_{fill\_cont}$	containers/h	60	–	–	–	–	See D.7.14
Drum Fill Rate	$RATE_{fill\_drum}$	containers/h	20	–	–	–	–	See D.7.14
Diameter of Opening – Container Cleaning	D_{cont_clean}	cm	5.08	–	–	–	–	See D.7.15
Diameter of Opening – Equipment Cleaning	D_{equip_clean}	cm	92	–	–	–	–	See D.7.15

Input Parameter	Symbol	Unit	Deterministic Values	Uncertainty Analysis Distribution Parameters				Rationale/Basis
			Value	Lower-Bound	Upper-Bound	Mode	Distribution Type	
Equipment Cleaning Duration	OH_{equip_clean}	h/day	0.5	–	–	–	–	See D.7.6
Penetrant User per Job	$Q_{penetrant\_job}$	oz/job	10.5	–	–	–	–	See D.7.16
Application Jobs per Day	N_{jobs_day}	jobs/day	8	–	–	–	–	See D.7.17
Percentage of Aerosol Released to Fugitive Air	$\%_{air}$	unitless	0.15	–	–	–	–	See D.7.18
Percentage of Aerosol Released to Uncertain Media	$\%_{uncertain}$	unitless	0.85	–	–	–	–	See D.7.18

D.7.3 Production Volume and Number of Sites

No sites reported to CDR for use of DBP in penetrants or inspection fluids. EPA estimated the total production volume (PV) for all sites assuming a static value of 215,415 lb/year (97,710 kg/year) that was estimated based on the reporting requirements for CDR. The threshold for CDR reporters requires a site to report processing and use for a chemical if the usage exceeds 5 percent of its reported PV or if the use exceeds 25,000 lb per year. For the 12 sites that reported to CDR for the manufacture or import of DBP, EPA assumed that each site used DBP for laboratory chemicals in volumes up to the reporting threshold limit of 5 percent of their reported PV. If 5 percent of each site's reported PV exceeds the 25,000 lb reporting limit, EPA assumed the site used only 25,000 lb annually as an upper-bound. If the site reported a PV that was CBI, EPA assumed the maximum PV contribution of 25,000 lb. The CDR sites and their PV contributions to this OES are show in Table_Apx D-13.

The number of sites is calculated using the following equation:

Equation_Apx D-46.

$$N_s = \frac{PV}{Q_{DBP_{year}}}$$

Where:

N_s	=	Number of sites (sites)
PV	=	Production volume (kg/year)
Q_{DBP_year}	=	Facility annual throughput of DBP (see Appendix D.7.4) (kg/site-year)

D.7.4 Throughput Parameters

The daily throughput of DBP in penetrants is calculated using Equation_Apx D-49 by multiplying the amount of penetrant per job by the number of jobs per day, density, and concentration of DBP. The amount of penetrant used per job is determined according to Appendix D.7.16. The number of jobs per day is determined according to Appendix D.7.17.

Equation_Apx D-47.

$$Q_{DBP\_day} = Q_{penetrant\_job} * N_{jobs\_day} * \frac{0.00781 gal}{oz} * 0.264 \frac{L}{gal} * RHO * F_{DBP}$$

Where:

Q_{DBP_day}	=	Facility throughput of DBP (kg/site-day)
$Q_{penetrant\_job}$	=	Amount of penetrant used per job (see Appendix D.7.16) (oz/job)
N_{jobs_day}	=	Application jobs of penetrant per day (see Appendix D.7.17) (jobs/day)
RHO	=	Density of DBP (assessed as density of the product) (kg/m^3)
F_{DBP}	=	Concentration of DBP in penetrants (see Appendix D.7.7) (kg/kg)

The annual throughput of DBP is calculated using Equation_Apx D-48 by multiplying the daily production volume by the number of operating days. The number of operating days is determined according to Appendix D.7.8.

Equation_Apx D-48.

$$Q_{DBP\_year} = Q_{DBP\_day} * OD$$

Where:

Q_{DBP_year}	=	Facility annual throughput of DBP (kg/site-year)
Q_{DBP_day}	=	Facility throughput of DBP (kg/site-day)
OD	=	Operating days (see Appendix D.7.8) (days/year)

D.7.5 Number of Containers per Year

The number of containers unloaded by a site per year is calculated using the following equation:

Equation_Apx D-49.

$$N_{cont\_unload\_year} = \frac{Q_{DBP\_year}}{F_{DBP} * RHO * \left(3.79\ \frac{L}{gal}\right) * V_{cont}}$$

Where:

$N_{cont\_unload\_year}$	=	Annual number of containers unloaded (container/site-year)
V_{cont}	=	Container volume (see Appendix D.7.11) (gal/container)
Q_{DBP_year}	=	Facility annual throughput of DBP (see Appendix D.7.4) (kg/site-year)
RHO	=	DBP density (kg/L)
F_{DBP}	=	Mass fraction of DBP in product (see Appendix D.7.7) (kg/kg)

D.7.6 Operating Hours

EPA estimated operating hours or hours of duration using data provided from the Emission Scenario Document on the Use of Metalworking Fluids (OECD, 2011c), ChemSTEER User Guide (U.S. EPA, 2015), and/or through calculation from other parameters. Release points with operating hours provided from these sources include unloading, container cleaning, equipment cleaning, and aerosol application.

For unloading and container cleaning (release points 1 and 3), the operating hours are calculated based on the number of containers unloaded at the site and the unloading rate using the following equation:

Equation_Apx D-50.

$$OH_{RP1/RP3} = \frac{N_{cont\_unload\_year}}{RATE_{fill\_drum/cont} * OD}$$

Where:

$OH_{RP1/RP3}$	=	Operating time for release points 1 and 3 (h/site-day)
$RATE_{fill\_drum/cont}$	=	Container fill rate, depending on container size (see Appendix D.7.14) (containers/h)
$N_{cont\_unload\_year}$	=	Annual number of containers unloaded (see Appendix D.7.5) (container/site-year)
OD	=	Operating days (see Appendix D.7.8) (days/site-year)

For equipment cleaning (release point 5), the ChemSTEER User Guide (U.S. EPA, 2015) provides a typical equipment cleaning duration of 0.5 h/day for cleaning a single, small vessel.
For aerosol application (release point 6), EPA treats this activity as container unloading. Therefore, EPA calculates the operating duration for this release using Equation_Apx D-50.

D.7.7 Penetrant DBP Concentration

EPA modeled DBP concentration in paints and coatings using a uniform distribution with a lower-bound of 10 percent and upper-bound of 20 percent. This is based on compiled SDS information for penetrants containing DINP. EPA was not able to identify products for this use that contained DBP. For that reason, EPA based the concentration estimate on compiled SDS information for penetrants and inspection fluids containing DINP and assumed that DBP-containing products would have similar concentrations ranges. The DINP-containing product is identified in Appendix F of the *Environmental Release and Occupational Exposure Assessment for Diisononyl Phthalate (DINP)* (U.S. EPA, 2024b).

D.7.8 Operating Days

EPA modeled the operating days per year using a triangular distribution with a lower-bound of 246 days/year, an upper-bound of 249 days/year, and a mode of 247 days/year. To ensure that only integer values of this parameter were selected, EPA nested the triangular distribution probability formula within a discrete distribution that listed each integer between (and including) 246 to 249 days/year. This is based on the Emission Scenario Document on the Use of Metalworking Fluids (OECD, 2011c). The ESD cites a general average for metal shaping operations to be 246 to 249 days/year, and it recommends a default value of 247 days/year.

D.7.9 Air Speed

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

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

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

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

D.7.10 Saturation Factor

The CEB Manual indicates that during splash filling, the saturation concentration was reached or exceeded by misting with a maximum saturation factor of 1.45 (U.S. EPA, 1991). The CEB Manual indicates that saturation concentration for bottom filling was expected to be about 0.5 (U.S. EPA, 1991).

The underlying distribution of this parameter is not known; therefore, EPA assigned a triangular distribution based on the lower-bound, upper-bound, and mode of the parameter. Because a mode was not provided for this parameter, EPA assigned a mode value of 0.5 for bottom filling as bottom filling minimizes volatilization (U.S. EPA, 1991). This value also corresponds to the typical value provided in the ChemSTEER User Guide for the EPA/OAQPS AP-42 Loading Model (U.S. EPA, 2015).

D.7.11 Container Size

EPA modeled container size using a triangular distribution with a lower-bound of 0.082 gallons, an upper-bound of 55 gallons, and a mode of 0.082 gallons. EPA identified penetrants in 10.5-oz (0.082-gallon) aerosol cans, and 1-, 5-, and 55-gallon containers. EPA used 10.5-oz cans as the mode because most products indicated using 10.5-oz cans. The product is identified in Appendix F of the *Environmental Release and Occupational Exposure Assessment for Diisononyl Phthalate (DINP)* (U.S. EPA, 2024b).

D.7.12 Container Loss Fractions

The EPA/OPPT Small Container Residual Model from the ChemSTEER User Guide (U.S. EPA, 2015) recommends a default central tendency loss fraction of 0.3 percent and a high-end loss fraction of 0.6 percent.

The underlying distribution of the loss fraction parameter for small containers is not known; therefore, EPA assigned a triangular distribution because triangular distributions are completely defined by range and mode of a parameter. The Agency assigned the mode and maximum values for the loss fraction probability distribution using the central tendency and high-end values, respectively, prescribed by the EPA/OPPT Small Container Residual Model in the ChemSTEER User Guide (U.S. EPA, 2015). EPA assigned the minimum value for the triangular distribution using the minimum average percent residual measured in the PEI Associates, Inc. study (Associates, 1988) for emptying drums by pouring.

D.7.13 Equipment Cleaning Loss Fraction

EPA used the EPA/OPPT Single Vessel Residual Model to estimate the releases from equipment cleaning. This model, as detailed in the ChemSTEER User Guide (U.S. EPA, 2015) provides a default loss fraction of 0.002 for equipment cleaning. In addition, the model provides non-default loss fractions of 0.01 and 0.0007. Therefore, developed a triangular distribution for equipment cleaning, with a lower-bound of 0.0007, an upper-bound of 0.01, and a mode of 0.002, based on the ChemSTEER User Guide (U.S. EPA, 2015).

D.7.14 Container Fill Rates

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

D.7.15 Diameters of Opening

The ChemSTEER User Guide indicates diameters for the openings for various vessels that may hold liquids in order to calculate vapor generation rates during different activities (U.S. EPA, 2015). For equipment cleaning operations, the ChemSTEER Manual indicates a single default value of 92 cm (U.S. EPA, 2015). For container cleaning activities, the ChemSTEER User Guide indicates a single default value of 5.08 cm for containers less than 5,000 gallons (U.S. EPA, 2015).

D.7.16 Penetrant Used per Job

EPA identified 10.5 oz as a standard size for aerosol cans. EPA assumed that one container is used per job, so the amount of penetrant used per job is 10.5 oz. The product is identified in Appendix E of the

Environmental Release and Occupational Exposure Assessment for Diisononyl Phthalate (DINP) (U.S. EPA, 2024b).

D.7.17 Jobs per Day

EPA assumed eight penetrant jobs occur per day. As there was no available usage data, EPA assumed a duration of 1 hour per job, and eight jobs/day due to a typical shift being 8 hours long. Therefore, EPA could not develop a distribution of values for this parameter and used the single value of eight jobs/day.

D.7.18 Percentage of Aerosol Released to Fugitive Air and Uncertain Media

According to the Generic Scenario on Chemicals Used in Furnishing Cleaning Products (U.S. EPA, 2022b), 15 percent of spray application releases are to fugitive air and 85 percent are to water, incineration, or landfill.

D.8 Inhalation Exposure to Respirable Particulates Model Approach and Parameters

The PNOR Model (U.S. EPA, 2021b) estimates worker inhalation exposure to respirable solid particulates using personal breathing zone Particulate, Not Otherwise Regulated (PNOR) monitoring data from OSHA's Chemical Exposure Health Data (CEHD) data set. The CEHD data provides PNOR exposures as 8-hour TWAs by assuming exposures outside the sampling time are zero, and the data also include facility NAICS code information for each data point. To estimate particulate exposures for relevant OESs, EPA used the 50th and 95th percentiles of respirable PNOR values for applicable NAICS codes as the central tendency and high-end exposure estimates, respectively.

Due to lack of data on the concentration of DBP in the particulates, EPA assumed DBP is present in particulates at the same mass fraction as in the bulk solid material, whether that is a plastic product or another solid article. Therefore, EPA calculates the 8-hour TWA exposure to DBP present in dust and particulates using the following equation:

Equation_Apx D-51.

$$C_{DBP,8hr-TWA} = C_{PNOR,8hr-TWA} \times F_{DBP}$$

Where:

$C_{DBP,8hr-TWA}$	=	8-hour TWA exposure to DBP (mg/m^3)
$C_{PNOR,8hr-TWA}$	=	8-hour TWA exposure to PNOR (mg/m^3)
F_{DBP}	=	Mass fraction of DBP in PNOR (mg/mg)

Table_Apx D-18 provides a summary of the OESs assessed using the PNOR Model (U.S. EPA, 2021b) along with the associated NAICS code, PNOR 8-hour TWA exposures, DBP mass fraction, and DBP 8-hour TWA exposures assessed for each OES.

Table_Apx D-18. Summary of DBP Exposure Estimates for OESs Using the Generic Model for Exposure to PNOR

Occupational Exposure Scenario	NAICS Code Assessed	Respirable PNOR 8-Hour TWA from Model (mg/m^3)		DBP Mass Fraction Assessed	DBP 8-Hour TWA (mg/m^3)	
		Central Tendency	High-End		Central Tendency	High-End
PVC plastics compounding	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.45	0.10	2.1
PVC plastics converting	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.45	0.10	2.1
Non-PVC materials compounding	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.20	4.6E−02	0.94
Non-PVC materials converting	326 – Plastics and Rubber Manufacturing	0.23	4.7	0.20	4.6E−02	0.94
Use of laboratory chemicals (solid)	54 – Professional, Scientific, and Technical Services	0.19	2.7	0.20	3.8E−02	0.54
Recycling	56 – Administrative and Support and Waste Management and Remediation Services	0.24	3.5	0.45	0.11	1.6
Fabrication or use of final product/ articles containing DBP	337 – Furniture and Related Product Manufacturing	0.20	1.8	0.45	9.0E−02	0.81
Distribution in commerce	48 to 49 – Transportation and Warehousing	7.6E−02	5.0	0.45	3.4E−02	2.3
Waste handling, treatment, and disposal	56 – Administrative and Support and Waste Management and Remediation Services	0.24	3.5	0.45	0.11	1.6

D.9 Inhalation Exposure Modeling for Penetrants and Inspection Fluids

This appendix presents the modeling approach and model equations used in the near-field/far-field exposure modeling of the use of penetrants and inspection fluids. EPA developed the model through review of the literature and consideration of existing EPA/OPPT exposure models. This model is based on a near-field/far-field approach (AIHA, 2009), where an aerosol application located inside the near-field generates a mist of droplets, and indoor air movements lead to the convection of the droplets between the near- and far-field. The model assumes workers are exposed to DBP droplets in the near-field, while occupational non-users are exposed in the far-field.

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

- Far-field size;
- Near-field size;

- Air exchange rate;
- Indoor air speed;
- Concentration of DBP in the aerosol formulation;
- Amount of product used per job;
- Number of applications per job;
- Time duration of job;
- Operating hours per week; and
- Number of jobs per work shift.

An individual model parameter could be either a discrete value or a distribution of values. EPA assigned statistical distributions based on available literature data. EPA used a Monte Carlo simulation to capture variability in the model parameters. EPA conducted the simulation using the Latin hypercube sampling method in @Risk Industrial Edition, Version 8.0.0. The Latin hypercube sampling method generates parameter values from a multi-dimensional distribution and is a stratified method, where the generated samples are representative of the probability density function (variability) defined in the model. EPA selected 100,000 model iterations to capture a broad range of possible input values, including values with low probability of occurrence.

Model results from the Monte Carlo simulation are presented as 95th and 50th percentile values in Section 3.12.4.2. The statistics were calculated directly in @Risk. EPA selected the 95th percentile value to represent high-end exposure level and the 50th percentile value to represent the central tendency exposure level. The following subsections detail the model design equations and parameters for the near-field/far-field model.

D.9.1 Model Design Equations

Penetrant/inspection fluid application generates a mist of droplets in the near-field, resulting in worker exposures at a DBP concentration C_{NF}. This concentration is directly proportional to the amount of penetrant applied by the worker standing in the near-field-zone (*i.e.*, the working zone). The near-field zone volume is denoted as V_{NF}. The ventilation rate for the near-field zone (Q_{NF}) determines the rate of DBP dissipation into the far-field (*i.e.*, the facility space surrounding the near-field), resulting in occupational bystander exposures to DBP at a concentration C_{FF}. V_{FF} denotes the volume of the far-field space into which the DBP dissipates from the near-field. The ventilation rate of the surroundings, denoted as Q_{FF}, determines the rate of DBP dissipation from the surrounding space into the outside air.

EPA denoted the top of each 5-minute period for each hour of the day (*e.g.*, 8:00 am, 8:05 am, 8:10 am, etc.) as $t_{m,n}$. Here, m has the values of 0, 1, 2, 3, 4, 5, 6, and 7 to indicate the top of each hour of the day (*e.g.*, 8 am, 9 am, etc.) and n has the values of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 to indicate the top of each 5-minute period within the hour. The worker begins the first penetrant application job during the first hour, $t_{0,0}$ to $t_{1,0}$ (*e.g.*, 8–9 am). The worker applies the penetrant at the top of the second 5-minute period $t_{m,1}$ (*e.g.*, 8:05 am, 9:05 am, etc.).

The model design equations are presented below in Equation_Apx D-52 through Equation_Apx D-72.

Near-Field Mass Balance

Equation_Apx D-52.

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

Far-Field Mass Balance

Equation_Apx D-53.

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

Where:

V_{NF}	=	Near-field volume (m^3)
V_{FF}	=	Far-field volume (m^3)
Q_{NF}	=	Near-field ventilation rate (m^3/h)
Q_{FF}	=	Far-field ventilation rate (m^3/h)
C_{NF}	=	Average near-field concentration (mg/m^3)
C_{FF}	=	Average far-field concentration (mg/m^3)
t	=	Elapsed time (h)

Solving Equation_Apx D-52 and Equation_Apx D-53 in terms of the time-varying concentrations in the near- far-field yields Equation_Apx D-54 and Equation_Apx D-54. EPA assessed Equation_Apx D-54 and Equation_Apx D-54 for all values of $t_{m,n}$. For each 5-minute increment, EPA calculated the initial near-field concentration at the top of each period ($t_{m,n}$), accounting for the burst of DBP from the penetrant application (if the 5-minute increment is during an application) and the residual near-field concentration remaining after the previous 5-minute increment ($t_{m,n-1}$; except during the first hour and $t_{m,0}$ of the first penetrant application job, in which case there would be no residual DBP from a previous application). The initial far-field concentration is equal to the residual far-field concentration remaining after the previous 5-minute increment. EPA then calculated the decayed concentration in the near- and far-field at the end of the 5-minute period, just before the penetrant application at the top of the next period ($t_{m,n+1}$). EPA then calculated 5-minute TWA exposures for the near- and far-field, representative of the worker's and ONU's exposures to the airborne concentrations during each 5-minute increment using Equation_Apx D-64 and Equation_Apx D-65. *k* coefficients (Equation_Apx D-55 through Equation_Apx D-59) are a function of initial near- and far-field concentrations and are recalculated at the top of each 5-minute period.

In the equations below, if n−1 is less than zero, the value at "m−1, 11" is used instead. Additionally, if n+1 is greater than 11, the value at "m+1, 0" is used instead.

Equation_Apx D-54.

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

Equation_Apx D-55.

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

Equation_Apx D-56.

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

Equation_Apx D-57.

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

Equation_Apx D-58.

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

Equation_Apx D-59.

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

Equation_Apx D-60.

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

Equation_Apx D-61.

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

Equation_Apx D-62.

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

Equation_Apx D-63.

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

Equation_Apx D-64.

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

Equation_Apx D-65.

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

After calculating all near-field/far-field 5-minute TWA exposures (*i.e.*, $C_{NF,5-\min TWA,t_{m,n}}$ and $C_{FF,5-\min TWA,t_{m,n}}$), EPA calculated the near-field/far-field 1-hour and 8-hour TWA concentrations according to the following equations:

Equation_Apx D-66.

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

Equation_Apx D-67.

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

Equation_Apx D-68.

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

Equation_Apx D-69.

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

EPA calculated rolling 1-hour TWAs throughout the workday, while the model reported the maximum calculated 1-hour TWA.

To calculate the mass transfer to and from the near field, the free surface area (FSA) is defined as the surface area through which mass transfer can occur. The FSA is not equal to the surface area of the entire near field. EPA defined the near-field zone to be a hemisphere with its major axis oriented vertically, against the application surface. The top half of the circular cross-section rests against, and is blocked by, the surface and is not available for mass transfer. The FSA is calculated as the entire surface area of the hemisphere's curved surface and half of the hemisphere's circular surface per Equation_Apx D-70:

Equation_Apx D-70.

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

Where:

R_{NF} = Radius of the near-field (m)

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

Equation_Apx D-71.

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

The far-field volume, V_{FF}, and the air exchange rate (AER) are used to calculate the far-field ventilation rate, Q_{FF}:

Equation_Apx D-72.

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

Using the model inputs described in Appendix D.9.2, EPA estimated DBP worker inhalation exposures in the near-field and ONU inhalation exposures in the far-field. EPA then conducted Monte Carlo simulations using @Risk Version 8.0.0 to calculate exposure results shown in Section 3.12.4.2. The simulations applied the Latin Hypercube sampling method using 100,000 iterations.

D.9.2 Model Parameters

Table_Apx D-19 summarizes the model parameters for the near-field/far-field modeling of the use penetrants and inspection fluids. Each parameter is discussed in further detail in the following subsections.

Table_Apx D-19. Summary of Parameter Values Used in the Near-Field/Far-Field Inhalation Exposure Modeling of Penetrants and Inspection Fluids

Input Parameter	Symbol	Unit	Constant Value	Variable Model Parameter Values				Rationale
				Lower-Bound	Upper-Bound	Mode	Distribution Type	
Far-Field Volume	V_{FF}	m^3	–	200	7.1E04	3,769	Triangular	See D.9.2.1
Air Exchange Rate	AER	m^3/h	–	1	20	3.5	Triangular	See D.9.2.2
Near-Field Indoor Air Speed	v_{NF}	cm/s	–	1.3	202	–	Lognormal	See D.9.2.3
		ft/min	–	2.6	398	–	Lognormal	
Near-Field Radius	R_{NF}	m^3	1.5	–	–	–	–	See D.9.2.4
Application Time	t_2	hr	0.0833	–	–	–	–	See D.9.2.5
Averaging Time	t_{avg}	hr	8	–	–	–	–	See D.9.2.6
DBP Product Concentration	F_{DBP}	kg/kg	–	0.10	0.20	–	Uniform	See D.9.2.7
Volume of Penetrant Used per Job	$Q_{penetrant\_job}$	oz/job	–	1.1	2.6	–	Uniform	See D.9.2.8
Number of Applications per Job	N_{app_job}	applications/job	1	–	–	–	–	See D.9.2.9
Number of Jobs per Work Shift	N_{jobs_day}	jobs/day	8	–	–	–	–	See D.9.2.11

[a] Each parameter is represented either by a constant value or a distribution.

D.9.2.1 Far-Field Volume

Since EPA was not able to identify any penetrant- or DBP-specific use or exposure data, EPA utilized a near-field/far-field approach (AIHA, 2009). The far-field volume is based on site visits of 137 automotive maintenance and repair shops in California (CARB, 2000). The California Air Resources Board indicated that shop volumes ranged from 200 to 70,679 m^3 with an average shop volume of 3,769 m^3. EPA assumed that the range of facility volumes in this data set would also be representative of other facility types that use DBP-based penetrants and inspection fluids Based on this data EPA assumed a triangular distribution bound from 200 to 70,679 m^3 with a mode of 3,769 m^3 (the average of the data from CARB).

CARB measured the physical dimensions of the brake service work area within each automotive maintenance and repair shop. CARB did not consider other areas of the facility, such as customer waiting areas and adjacent storage rooms if they were separated by a normally closed door. If the door was normally open, CARB considered these areas as part of the area in which brake servicing emissions could occur (CARB, 2000). CARB's methodology for measuring the physical dimensions of the visited facilities provides the appropriate physical dimensions needed to represent the far-field volume in EPA's model. Therefore, CARB's reported facility volume data are appropriate for the Agency's modeling purposes.

D.9.2.2 Air Exchange Rate

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

D.9.2.3 Near-Field Indoor Air Speed

Baldwin and Maynard measured indoor air speeds within 55 occupational settings in the United Kingdom (Baldwin and Maynard, 1998). EPA analyzed the air speed data from Baldwin and Maynard and categorized the air speed surveys into data representative of industrial facilities and data representative of commercial facilities. The Agency fit separate distributions for these industrial and commercial settings and used the industrial distribution for this model.

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

EPA's resulting lognormal distribution had a mean of 22.414 ± 19.958 cm/s, a minimum allowed value of 1.3 cm/s, and a maximum allowed value of 202.2 cm/s (largest surveyed mean air speed observed in Baldwin and Maynard). This was done to prevent the model from sampling values that approach infinity or are otherwise unrealistically small or large (Baldwin and Maynard, 1998).

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

D.9.2.4 Near-Field Volume

EPA defined the near-field zone volume (V_{NF}) as a hemisphere with its major axis oriented vertically against the application surface. EPA also defined a near-field radius (R_{NF}) of 1.5 m (≈ 4.9 feet) as an estimate of the working height of the application surface, as measured from the floor to the center of the surface.

Equation_Apx D-73.

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

D.9.2.5 Application Time

EPA modeled the application time at 5-minute intervals, as it is expected that the penetrant will be sprayed onto the surface, allowed to sit on the surface, and finally wiped away after the surface has been examined for defects. For this process, it is expected that the application step will only take 5 minutes.

D.9.2.6 Averaging Time

EPA uses 8-hour TWAs for its risk calculations; therefore, EPA used a constant averaging time of 8 hours.

D.9.2.7 DBP Product Concentration

EPA was not able to identify DBP-specific penetrant product information; however, the Agency assessed the DBP penetrant concentration using surrogate DINP concentration information from a penetrant and inspection fluid product, Spotcheck ® SKL-SP2. EPA used the SDS to develop a range of concentrations for the product (ITW Inc, 2018) and assessed the DBP product concentration based on this product, using a uniform distribution ranging from 0.1 to 0.2.

D.9.2.8 Volume of Penetrant Used per Job

EPA utilized a penetrant and inspection fluid containing DINP as surrogate and assessed the product information using the SDS (ITW Inc, 2018). Based on this information, the Agency estimated that the amount of penetrant per aerosol container was 10.5 oz. EPA then assumed the quantity of penetrant used per job as a uniform distribution ranging from 10 to 25 percent of can per job or 1.05 to 2.63 oz.

This throughput range differs from the throughput used to assess the releases for this OES as presented in Appendix D.7.4. The discrepancy reflects the expected discrepancy in the number of workers applying the product and working the job at a given site. EPA expects that these tasks will be performed by multiple workers per day, and that no one worker would regularly apply these products for a full shift. Thus, the 10 to 25 percent range results in less penetrant per job and is expected be more representative of aerosol exposures for a single worker.

D.9.2.9 Number of Applications per Job

EPA modeled the penetrant scenario with one application per job, as it is expected that the penetrant will be sprayed onto the surface, allowed to sit on the surface, and finally wiped away after the surface has been examined for defects.

D.9.2.10 Amount of DBP Used per Application

EPA calculated the amount of DBP used per application using Equation_Apx D-74. The calculated mass of DBP per application ranges from 2.09×10^{-3} to 4.17×10^{-3} g.

Equation_Apx D-74.

$$Amt = \frac{Q_{penetrant\_job} \times F_{DBP} \times 28.3495\,\frac{g}{oz}}{N_{app\_job}}$$

Where:

Amt	=	Amount of DBP used per application (g/application)
$Q_{penetrant\_job}$	=	Amount of penetrant used per job (oz/job)
F_{DBP}	=	Product concentration (kg/kg)
N_{app_job}	=	Number of applications per job (applications/job)

D.9.2.11 Number of Jobs per Work Shift

EPA did not identify DBP-specific data on penetrant and inspection fluid application frequency. Therefore, EPA assessed exposures assuming 8 jobs per work shift, which is equivalent to one job per hour for a full 8-hour shift. The full-shift assumption may overestimate the application duration as workers likely have other activities during their shift; however, those activities may also result in exposures to vapors that volatilize during those activities. Because EPA is not factoring in those vapor exposures, a full-shift exposure assessment is assumed to be protective of any contribution to exposures from vapors.

Appendix E PRODUCTS CONTAINING DBP

This section includes a sample of products containing DBP. This is not a comprehensive list of products containing DBP. In addition, some manufacturers may appear over-represented in Table_Apx E-1. This may mean that they are more likely to disclose product ingredients online than other manufacturers but does not imply anything about use of the chemical compared to other manufacturers in this sector.

Table_Apx E-1. Products Containing DBP

OES	Product	Manufacturer	DBP Concentration	Source	HERO ID
Adhesives and sealants	Devcon Weld-It All Purpose Adhesive	ITW Consumer – Devcon/Versachem	<3% by weight	Walmart (2019); ITW Consumer (2008)	6301538
Paints and coatings	Franklin Side Out Gym Floor Finish	Fuller Brush Company	<2%, unknown	Neobits Inc. (2019); Franklin Cleaning Technology (2011)	6301522
Non-TSCA (gunpowder)	Accurate Solo 1000, Accurate LT-30, Accurate LT-32, Accurate 2015, Accurate 2495, Accurate 4064, Accurate 4350	Western Powders, Inc.	0–10%, by weight	Western Powders Inc. 2015	6301493
Use of lab chemicals	Base/Neutrals Mix 1	SPEX CertiPrep, LLC.	0.2%, unspecified	SPEX CertiPrep LLC. 2019	6302556
Paints and coatings	Carbocrylic 3358-G	Carboline Company	1.0–2.5%, unspecified	Carboline Company 2018a	6301510
Paints and coatings	Carbocrylic 3359	Carboline Company	1.0 to <2.5%, unspecified	Carboline Company 2019a	6301494
Paints and coatings	Carbocrylic 3359 MC	Carboline Company	1.0–2.5%, unspecified	Carboline Company 2018b	6301531
Paints and coatings	Carbocrylic 3359 Mixed Metal Oxide	Carboline Company	1.0 to <2.5%, unspecified	Carboline Company 2019b	6301511
Non-TSCA (bullets)	Cartridge 9 mm FX Marking, Toxfree primer	General Dynamics – Ordnance and Tactical Systems – Canada Inc. [Canada]	Trace, unspecified	General Dynamics – Ordnance and Tactical Systems – Canada Inc. 2018	6301539
Use of lab chemicals	COE−RECT (Powder)	GC America Inc.	10–20%, unspecified	GC America Inc. 2015	6301521
Paints and coatings	CrystalFin Floor Finish	Daly's Wood Finishing Products	1%, unspecified	Daly’s Wood Finishing Products 2015	11438267
Use of lab chemicals	Custom 8061 Phthalates Mix	Phenova	0.1%, unspecified	Phenova 2017a	6301564

OES	Product	Manufacturer	DBP Concentration	Source	HERO ID
Use of lab chemicals	Custom Low ICAL Mix	Phenova	0.1%, unspecified	Phenova 2017b	6302481
Adhesives and sealants	D.L.M. Adhesive 22-68	Mon-Eco Industries, Inc.	1–5%, by weight	Mon-Eco Industries Inc. 2011	6301550
Use of lab chemicals	DEPEX Mounting Medium	Electron Microscopy Sciences	>2.5 to ≤10%, unspecified	Electron Microscopy Sciences 2018	6301529
Adhesives and sealants	Epcon Acrylic 7	ITW Red Head	0.1–5%, by weight	ITW Red Head 2016	6301527
Paints and coatings	Hydrostop Premiumcoat Finish Coat	GAF	0.1 to <1%, unspecified	GAF 2018	6301537
Paints and coatings	Hydrostop Premiumcoat Foundation Coat	GAF	0.1 to <1%, unspecified	GAF 2017	6301518
Paints and coatings	Hydrostop Trafficcoat Deck Coating	GAF	0.1 to <1%, unspecified	GAF 2016	6301526
Adhesives and sealants	Lanco Seal	Lanco Mfg. Corp.	0.05–10%, by weight	Lanco Mfg. Corp. 2016	6301543
Paints and coatings	Marine Coating Antifouling Blue	Rust-Oleum Corporation	2.5–10%, by weight	Rust-Oleum Corporation 2015	6301565
Adhesives and sealants	Metal Bonding Adhesive	Ford Motor Company	1 to <3%, unspecified	Ford Motor Company 2015	6301534
Use of lab chemicals	Phthalates in Poly(vinyl chloride)	SPEX CertiPrep, LLC.	0.3%, unspecified	SPEX CertiPrep LLC 2017a	6302509
Use of lab chemicals	Phthalates in Polyethylene Standard	SPEX CertiPrep, LLC.	0.3%, unspecified	SPEX CertiPrep LLC 2017b	6301560
Use of lab chemicals	Phthalates in Polyethylene Standard w/BPA	SPEX CertiPrep, LLC.	0.3%, unspecified	SPEX CertiPrep LLC 2017c	6301542
Adhesives and sealants	Prime Flex 900MV	Prime Resins Inc.	2.5 to <10%, unspecified	Prime Resins Inc. 2018a	6301547
Adhesives and sealants	Prime Flex 900XLV	Prime Resins Inc.	2.5 to <10%, unspecified	Prime Resins Inc. 2018b	6301561
Adhesives and sealants	Prime Flex 910	Prime Resins Inc.	50 to <75%, unspecified	Prime Resins Inc. 2018c	6301552
Adhesives and sealants	Prime Flex 920	Prime Resins Inc.	25 to <50%, unspecified	Prime Resins Inc. 2018d	6301541
Non-TSCA (bullets)	Rimfire Blank Round – Circuit Breaker	Olin Corporation – Winchester Division, Inc.	Unknown	Olin Corporation – Winchester Division 2010	6301545

OES	Product	Manufacturer	DBP Concentration	Source	HERO ID
Adhesives and sealants	Sika Loadflex-524 EZ Part B	Sika Corporation	≥50 to <100%, unspecified	Sika Corporation 2017	6301546
Paints and coatings	SWC Natureone 100% Acry EN CED	Structures Wood Care	2–3%, by weight	Structures Wood Care 2016a	6301556
Paints and coatings	SWC Natureone Renew	Structures Wood Care	2–3%, by weight	Structures Wood Care 2016b	6301548
Non-PVC materials	TC-4485 Part A	BJB Enterprises, Inc.	1–5%, by weight	BJB Enterprises 2019b	6301507
Non-PVC materials	TC-812 Part B	BJB Enterprises, Inc.	1–5%, by weight	BJB Enterprises 2018a	6301495
Non-PVC materials	TC-816 Part B	BJB Enterprises, Inc.	1–5%, by weight	BJB Enterprises 2019a	6301497
Use of lab chemicals	TempSpan Transparent Temporary Cement – Base	Pentron Clinical	5–10%, unspecified	Pentron Clinical 2014	6301544

Appendix F LIST OF SUPPLEMENTAL DOCUMENTS

A list of the supplemental documents that are mentioned in this *Draft Environmental Release and Occupational Exposure Assessment for Dibutyl Phthalate (DBP)* as well as a brief description of each of these documents is provided below. These supplemental documents include spreadsheets that contains model equations, parameter values, and the results of the probabilistic (stochastic) or deterministic calculations and are available in Docket EPA-HQ-OPPT-2018-0503.

1. *Draft Manufacturing OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP).*

2. *Draft Occupational Inhalation Exposure Monitoring Results for Dibutyl Phthalate (DBP).* This spreadsheet contains all of the inhalation monitoring data used to assess exposures to vapors and dust for each OES.

3. *Draft Occupational Dermal Exposure Modeling Results for Dibutyl Phthalate (DBP)*. This spreadsheet contains all model equations, parameter values and the results of the deterministic calculations of the worker dermal exposures to DBP that are associated with each OES.

4. *Draft Summary of Results for Identified Environmental Releases to Land for Dibutyl Phthalate (DBP).* This document contains identified land releases from TRI that were used in the release assessments for the majority of the OESs that are covered in the risk evaluation.

5. *Draft Summary of Results for Identified Environmental Releases to Air for Dibutyl Phthalate (DBP).* This document contains identified air releases from TRI and NEI that were used in the release assessments for the majority of the OESs that are covered in the risk evaluation.

6. *Draft Summary of Results for Identified Environmental Releases to Water for Dibutyl Phthalate (DBP).* This document contains identified water releases from TRI and DMR that were used in the release assessments for the majority of the OESs that are covered in the risk evaluation.

7. *Draft Application of Adhesives and Sealants OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP).*

8. *Draft Application of Paints and Coatings OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP).*

9. *Draft Use of Laboratory Chemicals OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP).*

10. *Draft Use of Lubricants and Functional Fluids OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP).*

11. *Draft Use of Penetrants OES Environmental Release Modeling Results for Dibutyl Phthalate (DBP).*

12. *Draft Use of Penetrants OES Occupational Inhalation Exposure Modeling Results for Dibutyl Phthalate (DBP).*